The Illinois

NATURAL HISTORY SURVEY REPORTS

NOVEMBER, 1962

One Hundred and Four Years Ago. The Natural History Society of Illinois, one of the first scientific institutions in Illinois to start work on the problems confronting its renewable natural resources, was founded in 1858. Another state scientific institution, the Office of the State Entomologist, was officially established in 1867 to combat losses inflicted by insects on the state's agriculture. In 1917 the continuing scientific bodies arising from these two organizations became the Illinois Natural History Survey.

In 1858 Illinois was a sparsely settled agricultural state. Now it is populous, highly agriculturalized, industrialized, and urbanized, and its recreational areas for hunting, fishing, and hiking have been reduced to an alarming degree. These changes have brought new problems regarding insect and plant pests, insects and human disease, the management of forests, the availability and use of game species in hunting and fishing, and the numbers and occurrence of other wildlife so dear to the naturalists and hikers of the state. Conditions in the state continue to change, and every change means a re-evaluation and re-orientation of the research activities of the Survey, in order to bring scientific knowledge to bear in solving new problems.

Many of the Natural History Survey's activities are relatively routine, such as censusing chinch bug or pheasant populations at periodic intervals. Other activities represent dramatic break-throughs in analysis and technology which give our scientists new tools for achieving a greater use of our resources. Sometimes natural events themselves take unexplainable and drastic turns and we must then strive to understand why these things happen and try to find out how to control them or adjust to them. In these reports we bring you glimpses of the unfolding drama of scientific inquiry which goes into the Survey's investigation of Illinois' natural resources.

Honker Time Again. By the middle of this month, Illinois' greatest "sport spectacular" will be with us again — the great flocks of Canada geese that winter in southern Illinois on refuges maintained by the State Department of Conservation. Over 200,000 birds are expected; 75 percent should be in the refuges by November 15, and the remainder will follow after the colder weather sets in farther to the north. Illinois sportsmen pursuing Canada geese spend approximately one million dollars in Alexander and Union counties alone.

The Canada goose flocks in Illinois are an international concern. The birds winter in southern Illinois, then fly north and breed along the muskeg land around Hudson Bay. The Indians hunt them on their breeding grounds; hunters in Ontario, Minnesota, Wisconsin, Iowa, Missouri, and Illinois hunt them on their southward journey. With modern, efficient firearms, this bird could be exterminated in a matter of a few years if unlimited hunting were allowed. Pressure from sportsmen and naturalists has led to a remarkable cooperative system by which this goose flock has gradually come to be managed with greater and greater precision. Operating under the federal and state laws governing the hunting of migratory waterfowl, goose harvests for individual provinces and states are determined by the Goose Committee of the Mississippi Fly-

way Technical Committee. Both committees are composed of biologists from the states along the Mississippi Flyway, the Province of Ontario, and the United States Fish and Wildlife Service. The Goose Committee integrates information on the size of the summer goose flocks and from this allocates the permissible harvest for each state. This year Wisconsin was allocated a harvest of 8,000; this number was reached and the Wisconsin season closed by the middle of October. Illinois has been allocated a harvest of 10,000.

New Goose Census Method. One of the big problems confronting attempts to manage this Canada goose population is the same one confronting city planners in estimating when to build new schools. This is the relative increase of young in the flock. Natural History Survey scientist Dr. Harold C. Hanson this year achieved a combination of photographic equipment by which he was able to estimate reliably the number of young produced per goose family. Dr. Hanson is figuratively the godfather of the Illinois Canada goose flock. For many years he has followed the geese from Illinois in winter to their breeding grounds in Canada in summer, then back to Illinois in autumn. His Canadian trips have been made in cooperation with the Arctic Institute of North America, the Ontario Department of Lands and Forests, and the Canadian government. Dr. Hanson is one of the leaders of the Goose Committee.

When Do Geese Begin to Breed? Barring muskeg fires in the northern breeding grounds, outbreaks of goose diseases, and other unpredictable natural phenomena, Dr. Hanson believes that we have now achieved 90 percent accuracy in predicting population levels of Canada geese. The harvest figures allotted by the Goose Committee are based on the limitations imposed by this figure. Dr. Hanson believes that if we could improve censusing methods to the point of 95 percent accuracy, the goose harvest could probably be doubled with safety. One of the biggest problems in predicting goose population levels has been the question: What percent of the geese breed when only two years old? Research on this question has been stymied by our inability to answer another question: When is a goose one year old, two years old, or three years old, and when is it sexually mature? As a reward for keeping his scientific nose to the grindstone, Dr. Hanson has finally discovered means of resolving some of these aging problems. This information is now in press as the *Natural History Survey Biological Notes No. 49,* entitled "Characters of Age, Size, and Sexual Maturity in Canada Geese." Prior to its publication, Dr. Hanson is tutoring other biologists along the Mississippi Flyway in the use of these characters so this information will be put to immediate use in obtaining a better understanding of this wild goose resource.

The Japanese Beetle. All evidence points to the fact that this international invader is well established in Iroquois County, Illinois, and in adjoining Indiana. Previous infestations of the Japanese beetle were found at Chicago, East St. Louis, and Mattoon, but these have not developed into large populations. The Japanese beetle was accidentally introduced into the United States along the eastern seaboard in 1916 and has expanded westward slowly but inexorably since that time. Many outlying populations were detected and eradicated by stringent control measures applied cooperatively by federal and state agencies. These activities slowed the tide of the beetle's spread; it was not until the 1950's that the Sheldon, Illinois, area was infested.

In the eastern states the beetle is a pest of ornamentals (trees, shrubs, and flowers) and fruit trees. If abundant, the adult beetles completely defoliate these plants and deform fruit. The young stages of the beetles are whitish grubs which feed on roots, preferably grass roots and may cause extensive damage to the fairways of golf courses, to cemeteries, and to lawns.

In the Illinois–Indiana area near Sheldon the adult beetles have caused heavy local defoliation of soybeans and have shown a great liking for corn silk. They feed on the silk down into the ear with destruction of potential kernels and deformation of the ears. In the eastern states this habit of feeding on corn is not serious. In Illinois, however, the high-yield hybrid has an ear in which the husk is relatively loose

and does not enclose the tip. Under conditions of high Japanese beetle population this type of ear is an open invitation to a potential damage of 25 percent of the crop.

In the East most of the adult beetles lay their eggs in turf; only a few adults lay eggs in open soil such as corn fields. Survey scientists Dr. G. C. Decker and Dr. W. H. Luckmann have observed that in Illinois almost all the females lay their eggs in open soil in soybean rows and corn rows. Dr. Luckmann says, "This drastic change in habits is evidence for suspecting that, in its approximately nine to ten years around Sheldon, the genetic strain laying eggs in open soil has become the dominant one. In other Illinois pests, such as the resistant onion maggot, such changes are often accompanied by other changes in habits, such as seasonal timing of the broods. From these suspicions plus the few observations on the habits of the Sheldon strain arise many questions which are important to understanding the impact of this Japanese beetle on Illinois agriculture." Dr. Luckmann points out that the grubs may cause considerable damage to corn roots but may pupate too early to be a menace to soybean roots. The adults, however, may normally emerge in number too late to do much ear damage to early strains of corn, but at just the right time to defoliate the soybeans. Thus the grubs may harm one crop and the adults, another. In August Governor Kerner released $6,500 of frozen funds which made it possible for Natural History Survey entomologists to initiate basic research which will give us information from this year's season, resulting in a year's head start in studying the beetle's habits and methods for its control.

Suffer From the Common Cold? So in a way do many of our worst insect pests. A large number of their virus, bacterial, and fungus diseases are fatal to them, and entomologists in many countries have been working diligently to find disease types which could be used as practical control measures against economic insects. Although this type of control would seem to be the answer to the problem of noxious insects, by and large it has proven only moderately effective. Some of the virus diseases have been marvelous in controlling pine and spruce sawflies. Other disease organisms have proven less successful. Some of them, such as the milky disease of the Japanese beetle, are extremely difficult and costly to culture and disseminate, and will maintain themselves in the field only if the population levels of their insect hosts are relatively high. Dr. John P. Kramer is the Natural History Survey scientist making a continuous search for microbiological parasites of Illinois insects which have potentialities for use in insect control.

During November Dr. Kramer is "on loan" as a consultant for the Division of Environmental Health of the World Health Organization. He will be visiting the world's foremost research centers in this field in France, Switzerland, Italy, West Germany, Czechoslovakia, England, Canada, and Florida. In addition to supplying WHO with valuable information drawn from the Survey's investigations, Dr. Kramer will get reciprocal help which will aid greatly our Illinois researches.

The Cock Pheasant Harvest. We have repeatedly been asked these questions: Why was the daily bag limit on cock pheasants in Illinois raised from two to three in 1959? Why was the pheasant season increased from 20 days to 25 days in 1961 and to 29 days in 1962? These liberalizations of regulations for pheasant hunting were not made because Illinois boasted of more pheasants than ever before, although pheasant populations are now fluctuating at a high level. Pheasant hunting was liberalized because our researches showed that fewer cocks were necessary to maintain pheasant populations than were being left in the field under the old rules.

The ring-necked pheasant is a polygamous species; that is, a single cock generally acquires, maintains, and defends a harem of several hens during the breeding season. The primary biological importance of the cock is to insure the fertility of eggs. Dr. T. G. Scott and his staff have shown that a ratio of one cock for every seven to ten hens in spring is sufficient to insure adequate production of chicks. This means that

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each fall at least 80 to 90 percent of the cock pheasants could, and should, be harvested by hunters. This is well substantiated by the fact that the greatest harvest in east-central Illinois occurred in 1961 after 77.1 percent of the cocks were removed by hunters; the poorest was in 1957 after only 27.6 percent were taken.

What happens to those cocks that are not shot by hunters? Intensive studies by the Survey's biologists show that *at least* 50 percent of the cocks alive at the end of a hunting season will die from various causes during the following winter, spring, and summer, and will not appear in the hunters' bags the following fall. Cock pheasants cannot be stockpiled from one hunting season to the next.

Elm Diseases. With present methods anyone trying to control the two diseases of elm in Illinois has two full strikes against him. Dutch elm disease is a fungus, and phloem necrosis is a virus. Each one is transmitted from tree to tree by either underground root grafts or by insects which have become infested with the disease organism by feeding on diseased trees. Methods for protecting healthy elm trees which have underground root grafts with diseased trees are difficult to apply effectively. Effective control of the diseases by killing their insect vectors requires spray programs which are hazardous to some forms of wildlife.

The ideal control of these diseases would be poisons which could be injected into the tree and which would kill the disease organisms without killing the tree. Dr. E. B. Himelick, Dr. Walter Hartstirn, and Dr. R. D. Neeley, three of the Survey's experienced plant scientists, and Dr. L. L. English, one of our oustanding entomologists, have been testing two sets of these internal poisons, called *systemics,* in the Survey's tree plots in an effort to control diseases of several kinds of trees. One set of systemics includes 32 organic compounds aimed at killing the fungus or the virus. A number of other systemics are aimed at killing the insects when they feed on the trees but before they can infect the tree with the disease organisms. The anti-disease compounds have shown no promise. One of the anti-insect systemics has shown some measure of disease control. Unfortunately, however, this compound has extremely adverse effects on the tree as well. We continue searching for a practical systemic.

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DECEMBER, 1962

The Lovely Carnation

Like apples and roses, carnation varieties do not breed true from seed, but must be propagated by cuttings. Carnations suffer from two common wilt diseases (one caused by a bacterium, the other by a fungus) which result in subnormal growth, stunting, or death. The diseases may not be apparent until the plant is practically in the bloom stage. In Illinois losses from these diseases range from 5 to 100 percent of certain varieties of carnations in many commercial greenhouses, often after the plants had been carried as growing stock for some time. Cuttings from diseased parent stock carry the diseases with them. By methodically culturing tiny bits of tissue taken from cuttings, the Survey's plant pathologist Dr. J. L. Forsberg achieved a method for detecting diseased stock long before the disease symptoms could be seen by visual examination. Use of this method enables disease-free carnation stock to be segregated and propagated under sterile conditions. As a result, disease-free carnation plants of most of the best varieties are now available to all carnation growers in the state. This carnation improvement program was undertaken cooperatively by the Illinois Natural History Survey, the Division of Floriculture of the University of Illinois, and the commercial flower growers of Chicago. In recognition of this work Dr. Forsberg received this year's American Carnation Society's Research Encouragement Award.

"Dr. Prairie Chicken"

A highlight for conservation was the dedication on November 12 of 77 acres northeast of Bogota in Jasper County, as a sanctuary for one of Illinois' most beloved birds, the prairie chicken. All connected with this activity were gratified that the sanctuary was named for the Survey's game scientist Dr. R. E. Yeatter, who has been studying these birds in Illinois for 27 years.

When Illinois was first settled, the farmers' grain fields were apparently much to the liking of prairie chickens which, about 1860, were abundant throughout the state. As hunting increased and farming became more intensive, their numbers dwindled, until in 1903 the hunting season was closed. About 1910, prairie chickens started a comeback, and a hunting season for them was opened in 1911, but their numbers again declined and the season was closed in 1933. Since then the birds have become almost a rarity. To succeed, prairie chickens need a particular combination of food and nearly undisturbed nesting cover; this combination of landscape has practically disappeared from the state. In recent years it was estimated that there were only about 2,000 birds in Illinois. The prairie chicken occurs west and northwest of Illinois, but in other parts of its range its numbers have also become drastically reduced. Dr. Yeatter began studying Illinois' populations of prairie chickens in 1935, following in especial detail the colony of these birds in Jasper County, and correlating the rise and fall of their numbers with local changes in agriculture. It seems certain now that this bird will never again be abundant in Illinois and that our problem is to save a few refuges on which the birds

can maintain themselves. To this end nature lovers from many organizations formed the Prairie Chicken Foundation of Illinois. Dr. L. J. Stannard, Survey entomologist and purchasing agent for the Prairie Chicken Foundation, was able to negotiate the purchase of the Jasper County sanctuary.

Mosquitoes

Up to the turn of the century malaria was important as a human disease in at least central and southern Illinois. The little one-celled organisms which cause malaria are carried from human to human only by certain kinds of mosquitoes known by the technical name *Anopheles*. In 1918, 1919, and 1920, Survey entomologists studied the habits of these mosquitoes and worked out methods for controlling them in an effort to reduce the malarial hazard in southern Illinois. With increased drainage of ponds and marshes where the *Anopheles* mosquitoes breed, aided by intensive control measures instituted in the southern and central states during World War II, malaria practically disappeared from this part of the continent.

The principal public health hazard in Illinois is now the possibility of an outbreak of encephalitis such as the recent one in Florida. These outbreaks, however, are sporadic, usually local, and completely unpredictable. Nuisance mosquitoes, however, have now become a serious threat to real estate values in many areas of the state, especially in or near large urban developments. A large number of mosquito abatement districts supported by local taxation are tackling this threat, and Survey scientists, in cooperation with the Illinois Department of Public Health, are again making basic studies of mosquitoes and their control.

Dr. H. H. Ross and Dr. G. C. Decker, Survey experts in mosquito identification and insect control, spoke at the mosquito control course given by fifteen scientists and field specialists at Lyons, Illinois, November 13–15. The course was presented by the Illinois Mosquito Control Association, in cooperation with the Illinois Department of Public Health, the Illinois Natural History Survey, and the U.S. Department of Health, Education, and Welfare; the Des Plaines Valley Mosquito Abatement District was the host institution. The aim of the course as explained by chairman Dr. R. A. Hedeen, South Cook County Mosquito Abatement District, was to keep the organizations concerned with mosquito abatement in northern Illinois abreast of new developments and techniques in mosquito identification, habits, and control methods, and to use this information in planning next year's control activities.

Frogs and Snakes

What conditions confronted prehistoric man in Illinois? Some clues on these questions came out of the recent study of the frog, toads, salamanders, newts, lizards, turtles, and snakes, made by the Survey's ichthyologist and herpetologist, Dr. P. W. Smith, and reported in the Survey's technical bulletin, *The Amphibians and Reptiles of Illinois*. It has won high acclaim nationally and has proven extremely useful to teachers in Illinois high schools, colleges, and universities. This bulletin gives keys for identifying the different kinds, illustrations of diagnostic characters, excellent photographs of each species known to occur in Illinois, information on the natural situations in which the various species are found, and detailed maps showing the Illinois distribution of each species. By a careful analysis of variation in different species of these animals, Dr. Smith found strong indications that some three or four thousand years ago Illinois was considerably warmer and drier than it is now, and that its prairie areas may have been much more extensive.

International Cooperation

During November and December, through the cooperation of the National Science Foundation and the Canadian government, the Canadian Department of Agriculture's eminent taxonomist Dr. J. F. McAlpine has been at the Survey finishing a joint problem with Dr. H. H. Ross concerning aquatic insects called caddisflies. The various kinds of insects living in streams, lakes, and ponds are indicative of the year-round conditions of these

bodies of water. This information is useful in assessing pollution. For half a century the Survey has been a center for studies establishing these indicator relationships. The first step in such studies is discovering the features by which the many thousand kinds of aquatic insects can be told apart, and it is on this phase that Dr. McAlpine and Dr. Ross have been working.

Water "Weeds"

A weed is often defined as "a plant growing where we don't want it." Some of our native plants grow in water up to several feet deep and add a picturesque fringe to lakes, streams, and ponds. At times these same kinds of plants may make such a dense growth in ponds and lakes that they interfere with swimming, boating, and fishing. Several mechanical devices including undergrowth mowers and grapples have been invented to try to get rid of these undesirable mats of vegetation, but the recuperative power of aquatic "weeds" is tremendous and these mechanical methods have been only partially successful.

With the appearance of many new terrestrial herbicides, it was inevitable that some of them would be effective on aquatic weeds. Survey biochemist Dr. Robert C. Hiltibran finds that most forms of rooted aquatic vegetation can probably be controlled effectively and economically with one or several herbicides. In his preliminary 1960 experiments, cattails bordering a 14.5-acre lake were controlled by two herbicidal compounds, *dalapon* and *amino triazole*. Curlyleaf pondweed, a terrific nuisance to power boaters and fishermen, was eliminated from a two-acre pond with another herbicide called *aquathol* applied at the rate of about one-part per million parts of water. *Diquat,* one of the newer aquatic herbicides, was effective on a wide variety of aquatic plants, including water primrose, water willow, sago pondweed, fineleaf pondweed, cattails, and Elodea; some species of plants were affected more rapidly than others.

The Natural History Survey has prepared a mimeographed leaflet on aquatic weed control which we will be glad to send on request.

Milky Disease

This is the famous bacterial disease which attacks and kills the Japanese beetle. Survey scientists are now working on plans to introduce experimental treatments of this disease in the Sheldon area where the Japanese beetle is established. How this disease will work in Illinois is largely guesswork, because the establishment of the disease depends on many factors, some of which are poorly understood. This situation was emphasized at a meeting held at the U.S. Department of Agriculture Laboratory at Peoria, November 15 and 16. Thirty experienced entomologists and bacteriologists, including Drs. G. C. Decker, W. H. Luckmann, and H. H. Ross of the Illinois Natural History Survey, discussed many aspects of the milky disease problem. In eastern states, dissemination of the hardy spore stage of this bacterial disease has resulted in a marked reduction of beetle populations. The expense (about $30 per acre at retail prices) and low potential supply of commercial spore "dust" rules out the feasibility of treating large areas with it at this time. Also there is a possibility that Illinois' long, cold winters may seriously retard its effectiveness after it is seeded into the soil. Spores are costly because to date they can be produced only in the body of the grubs or adults, an expensive technique. Efforts are now being made by USDA scientists to find either a cheaper method of producing the hardy spore stage, or some method of using the perishable vegetative stage which can be produced cheaply and abundantly in vat cultures.

Bugs Is Bugs

Over the years one of the most enjoyable pastimes of young people is making an insect collection. At first they catch the beautiful and showy butterflies and moths, then seek the larger beetles, flies, wasps, grasshoppers, and other large forms. Soon they "graduate" to the smaller forms of insects. The Natural History Survey for

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years has provided these young people, 4-H Club Leaders, high school teachers, and scout leaders with a handy manual giving guidance in making an insect collection. About a year ago our supply of this publication, our Circular 39, *How to Collect and Preserve Insects*, was exhausted. Now a revised edition is again available — single copies free to residents of Illinois, 25 cents out-of-state.

One Ten-Billionth

Since scientists discovered that even minute quantities of certain insecticides such as DDT may result in the accumulation and storage of these materials in the fatty tissues of animals, it has become extremely important to measure accurately any residues of these compounds in soil, pasturage, or fodder. Concerted study developed a series of tests by which one could measure the number of parts of DDT or other compounds per million parts of soil, plant or animal tissue. Some of the simplest and most efficient methods used colored solutions against which special preparations of the soil, plant tissue, or animal tissue were compared. Recently Survey scientist Dr. W. N. Bruce assembled a new testing device which is a modification of the commercial apparatus called an "electron capture" machine. In this, molecules of the chemical compound to be tested interefere with a stream of electrons through ionized nitrogen produced by atomic radiation with beta rays. These beta rays are called "soft radiation" because they are completely harmless to humans but nevertheless can be measured by the use of extremely delicate electrical instruments.

With this electron capture machine, 100 times more sensitive than the older colorimetric methods, Dr. Bruce can measure amounts as small as one ten-billionth of a gram. The Survey has been especially concerned with possible minute quantities of DDT and similar insecticides which may find their way into milk, vegetables, and meat intended for human consumption. This new machine gives us a faster and more accurate tool for this work.

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Newest Cattle Pest

The Japanese beetle gives the idea that newly introduced pests spread slowly. The face fly dispels the idea that this is a general rule. The first North American record of the face fly, of Eurasian origin, was found in Nova Scotia, Canada, in 1952. It moved rapidly southward and westward and was first found in Illinois in June, 1959. This last summer, a scant three years later, this fly was abundant and injurious in at least the northern two-thirds of the state.

This is a curious fly. Superficially it is extremely difficult to distinguish from the ordinary house fly; like the house fly it doesn't bite or sting. It injures primarily by causing irritation. The adult flies cluster around the eyes and noses of cattle, feeding on the damp, exposed membranes of these parts. If a cow has 20 or more flies around its head it expends a great deal of energy shaking its head, bunching up with other cattle, and generally fighting the flies.

Occasionally the flies cause acute conjunctivitis of the eyes which results in additional discomfort to the animals. When cattle are attacked by face flies, they do not graze properly resulting in reduced milk and beef production.

The flies lay their eggs in freshly dropped manure. The eggs hatch very soon into white, tapering maggots which feed in the manure and become full grown in four to five days. They then crawl away from the droppings, burrow down into the soil and transform into the resting or pupal stage. In another seven days the adult fly emerges and begins the cycle all over again.

Soon after the face fly became abundant in Illinois it was evident that none of the current fly control practices was effective against it. Survey entomologist Dr. W. N. Bruce turned his attention to modifying a syrup bait previously developed in the Survey laboratories for the control of house flies in barns and other buildings. The active poison used in this corn syrup bait is known as DDVP, which, for those of you who like long names, stands for dimethyldichlorovinylphosphate. Working closely with his fellow scientist Dr. S. Moore, within six months Dr. Bruce developed an effective bait, and the following year it was made commercially available to dairy farmers. While not the simplest method of procedure imaginable, the Survey-developed syrup bait applied daily to the face of dairy cows is still the most effective treatment known for face fly control. Best of all, in the amounts applied the bait poses no hazard to the animal, the user, or the consumer of meat or milk products. The only hazard lies in the possibility that someone might accidentally consume a quantity of the syrup bait.

Fly Finance

What does this situation of the face fly and its control mean in terms of dollars and cents? How does this fit into the economy of Illinois? These questions are answered by figures gathered by Dr. Bruce and Dr. Moore in the field tests which they made in cooperation with the University of Illinois Experiment Station and farmers of the state. In first considering the face fly, you might think that, causing only irritation, it would be of little con-

cern. The figures tell a different story. Last summer there were 450,000 head of dairy cattle in the infested area. With no control face flies caused a loss of one-half gallon of milk per cow per day, at least through all of July and August and usually during a considerable period of June and September as well. This loss represents 225,000 gallons of milk per day and 13.5 million gallons for a 60-day period in July and August. At the conservative price to the farmer of 30 cents a gallon, this is a loss of $4,050,000.

There are two million head of beef cattle in Illinois. Severe infestation causes a minimum loss of 20 pounds of weight per steer in the two-month peak period of face fly attack. Without any application of control measures this would have resulted in a July and August loss of 40 million pounds of beef which, at the conservative figure of 25 cents per pound, comes to at least $10 million. The potential loss of milk and beef poundage combined for July and August is therefore $14,050,000, not including eye problems resulting from face flies and not including losses incurred in the June and September periods of infestation, or by the highly susceptible spring calves (in Illinois almost all calving is done in the spring).

Under ideal conditions of application the new Survey baits practically eliminate the face fly; if they were uniformly applied throughout the problem area of the state they would theoretically save the entire loss on dairy cattle. In spite of the lowered effectiveness when used in actual practice farmers still realized a great savings from this new technique. In 1961 the treatment of dairy cattle resulted in halving milk production losses due to face flies. Feeder cattle are much more difficult to treat than dairy cattle, but even here this resulted in a saving of about 10 percent of the potential loss due to face flies. After subtracting the cost of treatment, the resulting score is a savings of $2,025,000 in milk production and $825,000 in beef production, with a total savings of $2,850,000 for the two worst months of the year. Counting in the end of June and the beginning of September, the annual saving to the Illinois producers was undoubtedly in the neighborhood of $3.5 million.

These are many dollars in the farmer's pocket, but the face fly is still close to $10 million ahead of the game. Survey entomologists are striving now to develop more effective methods and materials to combat the face fly on beef cattle. One study planned for 1963 involves mixing into the feed a chemical which will pass into the manure and prevent face fly maggots from developing.

Tick Talk

When December rolls around it is time for the deer hunters of Illinois to clean their guns, spruce up their hunting togs, and throw away their razors for a few days. To the Natural History Survey tick expert Dr. L. J. Stannard it is time to polish up his forceps and fill up a few vials with tick preservative.

North and west of Illinois, deer, cattle, and horses are the hosts of a tick which goes by the name of *Dermacentor albipictus,* commonly known as the winter tick because it occurs in large numbers chiefly during the cold months of the year. In Oklahoma, Arkansas, Missouri, and Texas this tick may reach unusual abundance, and in parts of Oklahoma this fall as many as 400 ticks per head of cattle were reported. At this level the ticks suck sufficient blood from the animal that they produce serious anemia and may cause a condition of coma called tick paralysis. To date, no known wild populations have become established in Illinois. Every deer season Dr. Stannard and his cooperators take their stands at the deer check stations and look for winter ticks on the deer brought in by hunters. If the winter tick became established in Illinois, these animals would give us a good idea where the tick populations were located and how abundant they were. This year over 300 deer were examined from Pope, Johnson, Union, Williamson, and Franklin counties in the south, and from Jo Daviess County in northern Illinois. No winter ticks were found.

Ole Man River

For years St. Louis has dumped its raw

sewage into the Mississippi River. According to Dr. W. C. Starrett, the Survey's expert on large-river ecology, this has created a pollution problem which has practically eliminated commercial fishing in the Mississippi as far down stream as Cairo. This year St. Louis approved $95 million for a model sewage treatment plant to be in operation possibly by 1964. This is the biggest single bond issue for this purpose ever to be approved by a community's voters. This plant should be a big factor in restoring populations of commercial and game fish in the St. Louis-Cairo stretch of the Mississippi River.

New Fish Book

Harold Titus, Conservation Editor, writes in the November, 1962, *Field & Stream:* "Probably more owners of farm ponds and artificial lakes have looked to the Illinois Natural History Survey and its biologist George W. Bennett for guidance than to any other source. Now Dr. Bennett has put his 25 years of research and observation into a book entitled *Management of Artificial Lakes and Ponds,* published by the Reinhold Book Division, New York." Especially valuable to the pond owners and lake managers of Illinois will be the chapters describing factors to be considered in choosing a site for new ponds or lakes, the various combinations of fish species recommended, theories and techniques of managing a population of fishes for satisfactory angling, and sound information concerning the commercial aspects of "renting" or "selling" fishing to sportsmen.

Ducks and Wetlands

In recent years the numbers of ducks passing through Illinois have steadily declined and duck hunting has deteriorated. Research on ducks by Survey wildlife scientists reveals that the problem lies north of Illinois on the breeding grounds. Ducks simply are not being produced in substantial numbers. Sixty-seven percent of the ducks that pass through Illinois are produced in the prairie wetlands of northern United States and southern Canada. Unfortunately, this area has been subject to drought since 1956 culminating in 1961, the driest year of all. In that year three-fourths of the ponds, potholes, and marshes on the northern plains dried up. Something else has been happening on the northern plains. Drainage for cultivation has removed thousands upon thousands of ponds and marshes. Drainage of wetlands is much more insidious than loss of wetlands from drought because lands drained for agriculture are lost permanently.

Drainage of prairie wetlands, so necessary for breeding waterfowl, has been much greater in the United States than in Canada. One of the principal reasons for the accelerated drainage program in the United States has been its encouragement by the U.S. Department of Agriculture. This has been in direct conflict with the program to protect wetlands for ducks sponsored by the U.S. Department of the Interior. The Agricultural Conservation Program of the U.S.D.A. has reimbursed farmers for one-half the cost of draining wetlands. This subsidized drainage of wetlands during the past 10 years has eliminated almost 50 percent of the region's 1,350,000 acres of waterfowl breeding habitat in North and South Dakota and in Minnesota. When the rains return, breeding ducks will be limited to the remaining ponds, potholes, and marshes. There will be far fewer places for the ducks to nest and rear their broods. Duck production will be lower in proportion to the wetlands that have been drained.

In 1961 the Congress authorized $105 million over a seven-year period for the purchase of wetlands. The funds, however, must be appropriated annually. No land can be acquired under this program without the approval of local and state governments. Because local governments fear loss of revenue by removing wetlands purchases from the tax rolls, few areas have been approved for acquisition. Bills submitted to Congress to help resolve this tax problem have not been passed. Some funds for the purchase of wetlands will come from the sale of Duck Stamps, but when hunting is poor, fewer stamps are purchased.

Some temporary protection to wetlands in North and South Dakota and Minnesota is given by Public Law 86-732,

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which prohibits the Secretary of Agriculture from providing financial or technical assistance for wetland drainage if the Secretary of the Interior has found that waterfowl production would be materially harmed. If the U.S. Fish and Wildlife Service finds that drainage would materially harm wildlife, it has one year in which to make a reasonable offer to purchase or lease the area. This acquisition of wetlands needs to be accelerated if duck populations are to make a real comeback. Future flights of Illinois ducks depend to a large extent on current programs aimed at saving wetlands.

Alfalfa Feeder

Efforts to track down the winter survival quarters of the little migratory insect called the potato leafhopper, which causes substantial annual losses to alfalfa every summer in Illinois, have led Survey entomologists and their cooperators far afield. This insect passes the winter far south of Illinois. Our present winter sampling extends south to Puerto Rico and Costa Rica; the last important area from which we need information is the northern coast of South America. To obtain information and material from this latter area, the Rockefeller Foundation has cooperated by awarding a travel grant to Survey entomologist Dr. H. B. Cunningham. He will collect these little insects in Colombia and neighboring South American countries during December and January.

If we learn enough about the overwintering areas of these leafhoppers and the mechanics of their annual spring migration into Illinois, we will be able to predict in spring the summer build-up of this pest on Midwest alfalfa. This in turn would be valuable to farm planning. As our agriculture becomes more intensive, this type of information will have a higher economic value.

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The Illinois

NATURAL HISTORY SURVEY REPORTS

FEBRUARY, 1963

Subterranean Insects

As you admired miles and miles of green and waving corn, did you ever stop to think that the "toes" of every corn plant might be getting chewed off by small insects in the soil?

Unseen and frequently unnoticed, many kinds of insects do feed on the sprouting seed and roots of the corn plant — corn seed maggots, some dozen or more different kinds of white grubs, as many different kinds of wireworms, corn rootworms, and many other less well-known insects. At times this root feeding becomes so severe that the plants die; most of the time the feeding simply reduces the vitality of the corn without any conspicuous symptoms appearing in the parts of the plant above the ground. Ten years ago, Survey entomologist Dr. G. C. Decker and his staff began studies on the usefulness of insecticides in the control of these subterranean insects that attack corn. In 1954 their cautious control recommendations were picked up for trial by curious and progressive farmers. From this humble beginning, each year the program has grown in size and reliability. The extent of the success of this program is reflected in the following tabulation of treatments made in the last five years (1958–1962) aimed at controlling subterranean insects attacking Illinois corn. (No other crops are included in this tabulation.)

Year	*Illinois Acres Treated*	*Estimated Profit Due to Treatment*
1958	780,383	$ 1,950,957
1959	1,325,196	3,975,588
1960	1,891,399	5,674,197
1961	2,573,812	7,721,436
1962	3,505,122	14,020,488

The column for estimated profit is the profit over and above the cost of treatment. These figures are based on the differences in yield between treated and untreated corn fields. Survey entomologists J. H. Bigger and H. B. Petty point out that the collection of these data is a massive undertaking that would not be possible without the cooperation of many farm advisors and individual farmers throughout the state.

Air Lanes of the Wild

How do birds navigate when they migrate southward in the fall and northward in the spring? Records from banded birds show that ducks, geese, and other migrators normally return with remarkable accuracy to their summer breeding grounds and fly with equal accuracy to their wintering grounds in the south. Do the birds follow topographic features such as rivers and lakes, or do they have some other means of navigation?

Trying to solve this problem, Survey biologist Frank C. Bellrose has been tricking birds by trapping them at Havana, Illinois, then either holding them there longer than usual or moving them east or west several hundred miles, releasing the birds, and then comparing the migration paths of these disoriented birds with normal flights. He has accumulated remarkable evidence that the birds navigate by orienting themselves with celestial bodies, especially with the point on the horizon where the sun rises or sets, and possibly by other orientations which the birds sense regarding time of day and the relative position of celestial bodies.

Originally these studies were carried out with visual observations using binoculars. With this method the released waterfowl could be followed for only two or three miles at best, and this only under ideal weather conditions. Later three aircraft-type radar units were obtained. These can follow released birds as far as four miles in most kinds of weather. One of these units is located at Champaign, one at Havana, and the third unit is mounted in a truck so it can be run along highways to any desired location.

Recently the National Science Foundation made available to the Illinois Natural History Survey an army surplus M-33 radar unit. This M-33 unit, with a book value of $373,800, will give us a big boost in radar instrumentation for tracking released waterfowl and for finding out normal migrating paths for waterfowl and smaller birds throughout the Midwest. The M-33 radar is many times more powerful than our aircraft-type radar units. We anticipate that the M-33 will register large targets of birds up to 25 miles away. This will be of tremendous value in finding out from what direction the fall waterfowl flights arrive at the Mississippi and Illinois River valleys, especially when they are invisible to the eye because of low clouds or fog. Mr. Bellrose is especially anxious to get this information on migration behavior under adverse visibility because this should tell a great deal about whether celestial orientation or map orientation is more important in bird migration. It may tell us that birds also use other means of navigating in migrating hundreds of miles to a specific location.

The M-33 radar has another feature which will be especially valuable in the Survey's study of bird flight patterns. It can lock on and plot the flight path of a selected bird target. This means that the flight path of an individual duck or goose can be traced for 25 or 30 miles after the bird has been released under a variety of conditions, such as when it is away from water, when it is under various sky conditions, or when released at various times of day. In this bird migration study, already assisted for several years by the National Science Foundation, the Survey has recently secured another ally, the U.S. Weather Bureau. Mr. Hal Foster, Chief of RADU, and Mr. Henry Jacobson, Chief Forecaster at Kansas City; Mr. George Brancato, Meteorologist in Charge at St. Louis; and Mr. C. E. Lamoureaux, Meteorologist in Charge at Des Moines, are using their powerful weather search radars to sample the nocturnal sky for bird migrations. They will duplicate and send to the Survey films made of the radar displays during various sampling periods. Perhaps with these new tools and the efforts of many people we will finally find out how much these birds know about where they are going and how they get there.

Board Meeting

The Board of Natural Resources and Conservation held its winter meeting in Chicago on January 23, and considered the quarterly reports presented by the chiefs of the three state scientific surveys, the Geological Survey, Natural History Survey, and Water Survey. These three surveys, organized as Divisions of the State Department of Registration and Education by the Board at its first meeting on December 15, 1917, are headquartered on the University of Illinois campus and are instructed to cooperate with the University of Illinois and other state agencies, and with the Federal Government.

The Board now consists of eight members:

- Director William Sylvester White of the Department of Registration and Education, who is chairman of the Board, at times represented by Assistant Director John S. Watson;
- The President of the University of Illinois, represented by Dean William L. Everitt:
- The President of Southern Illinois University, represented by Dean Henry Dan Piper; and experts in each of the following fields:
- *Geology:* Walter H. Newhouse, former chairman of the Department of Geology, University of Chicago, and geological expert, who specializes among other things in the structural relations and origin of ore deposits;

The Board of Natural Resources and Conservation at its quarterly meeting in the Chicago office of the Department of Registration and Education, on January 23, 1963. From left to right: *Standing* — Dean Piper, Assistant Director Watson, and Director White; *Seated* — Dr. Adams, Dean Everitt, Mr. Anderson, Dr. Olmsted, and Dr. Park. Other regular attendants at the Board meeting were the chiefs of the three surveys and the Director's secretary. Dr. Newhouse was absent due to illness.

• *Chemistry:* Roger Adams, former head of Department of Chemistry, University of Illinois, and member of the National Academy of Science, an organic chemist whose researches cover a wide range of fields and who is probably most famous for Adam's catalyst for hydrogenation, widely used in industry;

• *Engineering:* Robert H. Anderson, consulting engineer, St. Charles, Illinois, for many years consultant on water and engineering problems to cities and towns in the Fox and Des Plaines River valleys;

• *Biology:* Thomas Park, Professor of Zoology, University of Chicago, recently president of the American Association for the Advancement of Science, pioneer in the experimental biology of natural populations;

• *Forestry:* Charles E. Olmsted, chairman of the Department of Botany, University of Chicago, ecologist whose specialties include factors controlling the structure of forests and the physiological ecology of grassland.

The Board has three regular meetings each year. At this meeting it considered various administrative matters concerning the three surveys and reviewed their scientific findings since the last Board meeting on October 3, 1962.

Live African "Herbicide"

Winter visitors to the Natural History Survey's live fish room in the Natural Resources building wonder at a large tank of African fishes called *tilapias* or mouth breeders.

This cichlid, which somewhat resembles a sunfish, was imported by Alabama fishery biologists for testing its value as a means of controlling excessive algae and rooted vegetation in ponds. We obtained some stock from this source for testing in a two and a half acre pond having a dense crop of aquatic vegetation. In mid-May aquatic biologist William Childers introduced 150 small fish totalling three pounds into the pond. By September these voracious fish had increased to 28,000 individuals totalling 1,006 pounds, or 387 pounds per acre, and had eaten every trace of vegetation in the pond.

Tilapias are of particular interest because they carry their eggs in their mouths. When ready to reproduce, a male digs a nest similar to that of the sunfishes, where spawning takes place. After the eggs are deposited in the nest, they are picked up and carried in the fishes' mouths. When the eggs hatch and the young swim freely, they still may seek the mouths of their parents for protection from danger. Individual fish may attain a size of more than a pound.

Because of their rapid growth and reproduction, tilapias are used as a food fish in tropical Asia and Africa. In this country they may become important in vegetation control, and perhaps to a limited

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extent as a food fish. The chief drawback to their use is that they are unable to withstand water temperatures much below 50° F. and cannot survive Illinois winters out-of-doors. Even in Alabama they must be moved indoors through the winter.

Current Currants

A fungus disease nearly "knocked out" alpine currant, a shrub and hedge plant highly favored by landscapers, home owners, and nurserymen because of its symmetrical shape, dense foliage, freedom from insect pests, and formerly thought free from disease. This currant, whose technical name is *Ribes alpinum,* was used extensively in landscape plantings throughout the northern half of Illinois, particularly in the Chicago area. In the early 1950's, however, a fungus disease known as anthracnose appeared in the Chicago area and began to spread to many of the commercial nurseries. By 1959 the severity of the disease had caused several nurserymen to stop production of this highly desirable plant and was threatening to eliminate alpine currant as a desirable ornamental species in Illinois.

As soon as the alpine currant problem was recognized, Survey plant pathologist Dr. Donald F. Schoeneweiss designed a series of experiments directed toward finding an effective, practical control measure for this disease. Extensive spray tests conducted with the cooperation of many nurserymen in the state, especially in nurseries of the Chicago area, demonstrated that excellent control could be achieved through the proper application of any one of five commercially available fungicides. The key to this success was finding the time when the fungicide applications coincided with certain weak links in the life history of the disease organism. By the fall of 1960, Dr. Schoeneweiss had devised a spray control program which follow-up tests show to be adequate and practical under Illinois conditions. As a result, Illinois nurserymen can again offer this well-liked ornamental with the knowledge that if the plant becomes infected with anthracnose before or after sale, the disease can be brought under control and even eliminated by the diligent use of well-tested control measures.

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MARCH, 1963

Tick Warning

With the break of winter, the potentially dangerous wood tick, called *Dermacentor variabilis*, will become active and seek a blood meal from most any large vertebrate animal it can find, including man. This tick is an especially dangerous threat to human health because during feeding it can transmit the parasite causing Rocky Mountain spotted fever. Over the past 20 years, almost every county in Illinois has reported human cases of this disease, and occasionally death has resulted. In addition, this tick may cause paralysis which can be fatal to human beings and to livestock. One tick, while feeding, can paralyze a grown man or a 1,000-pound cow. The mechanism of tick paralysis is still unknown to science.

In his comprehensive studies of the many kinds of ticks occurring in Illinois, Survey entomologist L. J. Stannard has found that the wood tick is the only common Illinois tick which attacks man. According to Survey records, adults of the species lie in wait for a host animal from late February (in southern Illinois) to August. Few are present in September or during the fall. Found along the forest edge and in brushy places, these ticks are extremely abundant throughout southern Illinois and are locally numerous in northern parts of the state.

Once on a person, the wood tick is apt to wander in search of a good feeding spot for several hours before making the initial penetration into the victim's skin. Ordinarily only the female — distinguished by a silver disk behind the "head" — feeds. On persons, a favorite feeding spot is at the base of the head at the hairline. Ticks walk on skin and bite so lightly that many people do not even feel them. They may remain feeding for several days before total engorgement occurs.

Dr. Stannard cautions persons who will be out-of-doors in Illinois this spring and summer to remove all ticks from their person daily, preferably before the ticks settle down for feeding. Many of the wood ticks encountered may not be carrying fever-producing organisms, but potentially all can.

This Goose's Goose Wasn't Cooked

Hottest thing in the Survey's halls right now is speculation about a comeback for the Giant Canada goose going under the scientific name *Branta canadensis maxima*. Tales of 80 years ago mentioned a big Canada goose in the Great Plains, but most of these stories were usually put into the category of "fishing exploits." Several

Unfed female of the wood tick. Note the silvery shield behind the very small head and the four legs. The tick is brown and about 1/5 of an inch long.

years ago, a few skins of Canada geese in the American Museum of Natural History (New York) were recognized as being larger than usual and considered as belonging to a previously undescribed race of our northern migrant Canada goose by the noted ornithologist Gene Delacour. At this time the "Big Goose" was thought to have been extinct since about the turn of the century.

Accounts of a flock of unusually large geese wintering over in Rochester, Minnesota, excited the curiosity of scientist Dr. Harold C. Hanson, the Survey's goose expert, and led to a study of this flock and efforts to ascertain its identity. Following Dr. Hanson's comparison of skins of geese from this flock with skins in large museums in the East and at the Chicago Museum of Natural History, it was concluded that the flock at Rochester was composed of *Branta canadensis maxima,* once believed to be as extinct as the Dodo. Subsequently, the U.S. Bureau of Sport Fisheries and Wildlife made it possible for Dr. Hanson to study captive flocks on a number of Federal Refuges in Minnesota and the Dakotas. These flocks also proved to be *maxima* — in fact, it is now recognized that various captive flocks on farms and those of game breeders in the north-central states, which in many cases are the descendants of old decoy flocks, are also *maxima.*

Yes, there *is* a Giant Canada goose and it is still part of our living heritage. The very large ganders of this race reach weights ranging from 15 to 19 pounds and achieve wingspreads up to 6½ feet. Occasionally a few even larger have been reported. Characteristics of the race include very long necks, long swanlike bodies, light coloration, massive spoonlike bills, and unusually large feet. They have prominent white neck rings rather than dusky white rings as in other races and, frequently, a white mark across the forehead or white spots above the eyes.

This is the same goose which was once common on our northern prairies together with buffalo and elk. Early accounts repeatedly mentioned these geese being held in semi-domestication by the Indians of the region and by the early settlers. Before the agriculturalization of the Midwest, the giant goose bred from Reelfoot Lake, Tennessee; along the Ohio River in Kentucky, where Audubon knew it; north to Michigan, Wisconsin, Minnesota, the Dakotas, and Manitoba; west to Nebraska, and across the Canadian prairies to the Rockies. There was undoubtedly a large breeding colony of these geese in the Kankakee marshes and in the Calumet marshes before Chicago began its phenomenal growth.

The Giant Canada goose is extremely hardy and can withstand severe weather so long as food is obtainable. The northernmost populations tend to migrate to widely separated parts of the United States. Many of those in Alberta, where 10,000 are reported nesting, migrate into California. Some flocks in southern Manitoba go down the Missouri River and a few reach the Gulf Coast. Others summering in eastern and central Manitoba migrate to Rochester, Minnesota, and Rock County, Wisconsin, where in recent years 4,000 to 5,000 have been wintering at each locality.

Considered extinct only a year ago, the "Big Goose" will soon become one of our best known races of Canada geese. It may even become a familiar sight again to Illinois naturalists. Survey scientists and the State Department of Conservation will attempt to re-establish this goose in suitable areas of Illinois. Results of this project should be most intriguing.

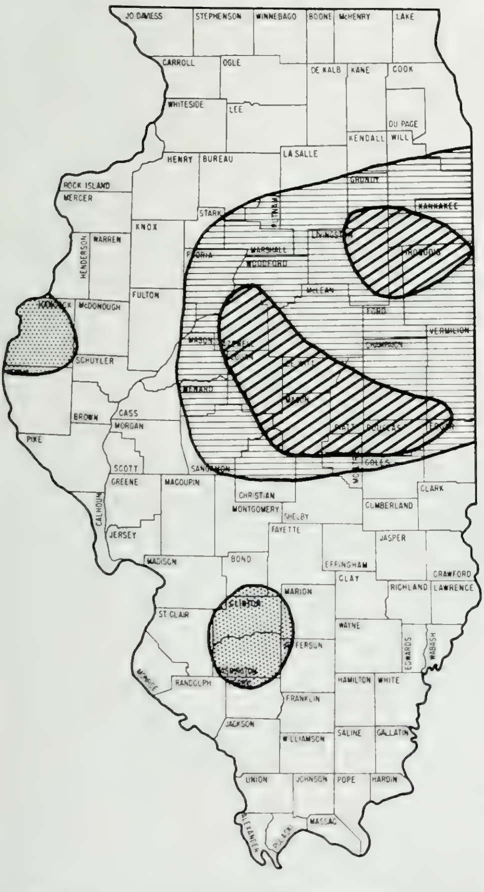
Insect Survey Bulletin

Everyone seems to want to know what the weather forecast is going to be and to some people accurate weather predictions are a great business asset. Thousands of families in Illinois would like to know what the predictions of insect abundance are going to be, especially the species which have the potential of causing costly losses to agricultural crops, livestock, and ornamentals. To these farmers and others, it is highly advantageous to have a few days' or a week's warning as to when control measures may need to be applied against insect pests.

During the spring and summer months, entomologists of the Survey and University

of Illinois College of Agriculture, circulating throughout the state, make weekly counts of insect numbers on field crops, livestock, and important ornamentals. Cooperators making observations in their own localities also add information which helps in the determining of general trends in insect populations in Illinois. The information gathered by the entomologists and cooperators is summarized in a weekly bulletin starting in April and continuing through August. Dr. H. B. Petty, Survey entomologist and professor of agricultural entomology, will be editing the *Insect Survey Bulletin* which each week will report the current situation and offer recommendations for insect pest control.

During the course of a season, as many as 50 different insect pests have been highlighted in the Bulletin. Those commonly dealt with include bag worms, red spiders, elm leaf beetles, corn borers, grasshoppers, chinch bugs, aphids, army worms, stable flies, houseflies and face flies, as well as many others. The Bulletin delineates areas of the state where these insect pests are approaching threatening numbers. It also reports on areas where insect pest populations are decreasing and appear to be no longer a cause for concern. When the use of an insecticide is recommended, the Bulletin specifies where the insecticide may safely be applied, as well as pointing out any other restrictive limitations of the treatment.



Present outlook for chinch bug prevalence in 1963. Unmarked areas, below economic levels; dotted areas, light losses probable; horizontally lined areas, light to medium losses probable; diagonally lined areas, severe losses probable. The *Insect Survey Bulletin* is based on sampling of this type.

Elms and Iodide

A new method of treatment promises to give some relief to tree-removal crews following in the wake of Dutch elm disease. The fungus causing this disease is spread from diseased to healthy trees by elm bark beetles, whose young live inside and feed on the bark of the elms. The first prerequisite for control of the disease is prompt removal and destruction of diseased trees before the bark beetles in them can mature, fly to healthy trees, and spread the malady. In summer a brood of beetles matures in only three months. If a town has a sudden and large number of trees attacked by the disease, it is often necessary to hire extra tree-removal crews in order to achieve good sanitation. Although this is expensive, failure to remove the diseased trees undermines the efficiency of the entire control program.

In many municipalities this problem is compounded by wild elms which grow in wooded areas along nearby rivers and creeks. If uncontrolled and neglected, elms in these areas become diseased and serve as prolific sources of contaminated bark beetles which can fly into town and there inoculate healthy trees. In these wild areas it is frequently almost impossible to use spray control methods because of difficulty in maneuvering heavy equipment, and often equally difficult to fell and burn the diseased trees. In recent years it was found that if sodium arsenite solution was applied to ax frills made at the base of the tree, it would be trans-

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ported throughout the tree and would forever prevent development of bark beetles in it. The treatment kills the tree but removes it as a source of infection and deletes the necessity of felling and burning it.

This method was unusable in populated areas because sodium arsenite is a violent poison to pets and humans. In recent Survey tests, Dr. E. B. Himelick and Dr. R. D. Neely found that a solution of potassium iodide gave practically as good results without the danger of accidental poisoning. Cooperative tests with the Cook County Forest Preserve District demonstrated that if diseased trees can be detected in the very early stages of Dutch elm disease and poisoned with potassium iodide, few or no bark beetles mature in them and none later invade them. The treated trees can be left standing any desired length of time and all the diseased trees of a season cut and removed systematically on a year-round basis employing a minimum crew.

It must be emphasized that this treatment works only if trees are treated in the earliest stages of the disease, when they are still sufficiently healthy to have good sap flow which will carry the iodide to all parts of the tree. If diseased trees are detected too late for this treatment, the sanitation practice of prompt removal and destruction is a *must* for helping to control the disease.

Because of the high toxicity of sodium arsenite to wildlife, substituting potassium iodide for it in the treatment of wild stands of elm should be of great benefit to woodland species of mammals and birds.

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APRIL 1963

Worm-eating Worms

Two truly weird friends have come to the aid of an Illinois greenhouse owner by helping to reduce earthworms, the cause of "puddling" or compacting of the bench soil. These new friends are known as land planaria, a kind of flatworm. Among the most primitive organisms known to science, flatworms are the first up the evolutionary scale having bilateral symmetry, meaning that both sides of the body are similar. Some flatworms, including the human tapeworms and flukes, are internal parasites of men and livestock. Certain non-parasitic flatworms, including the land planaria, are carnivorous and feed exclusively on other worms.

This winter Survey scientists J. L. Forsberg and L. J. Stannard found two of the world's largest species of flatworms in an Illinois greenhouse. Identified in a rose greenhouse in Rochelle, Ogle County, these land planaria — some of which measure nearly a foot in length — are the first to be found in Illinois. Native to jungles in Indo-Malaya, both of these planaria have been distributed accidentally in commerce throughout the tropical regions of the world and have occasionally become established in a northern greenhouse. In the United States they are found out-of-doors in California, Louisiana, and Florida, but their appearance in the Rochelle greenhouse is the first record of their occurrence in the Midwest.

One of these flatworm species, called *Bipalium kewense,* is a pale yellowish-brown with seven dark dorsal stripes and has a triangular head shaped somewhat like an arrow point. The other species, called *Dolichoplana striata,* is grey in color and also has dark dorsal stripes. Its blunt tapering head bears a pair of black eye spots. The mouths of both species are located on the ventral surface a considerable distance behind the head. When feed-

Above, striped flatworm, extended and "on the prowl"; about eight inches (20 centimeters) long. *Below,* flatworm (note the widened head) exploring part of an earthworm prior to "eating" it. (Photos by Wilmer Zehr.)

ing, the flatworm crawls along an earthworm, then expands and seems to almost envelop large parts of it. After awhile the earthworm is reduced to a shapeless residue and the flatworm moves off in search of another meal.

Hybrid Sunfish

The great goal in fish management is to produce a tremendous number of large fish fast. When current methods of fish management fall short of expectations, there is an increasing current of opinion that the use of hybrids would achieve the goal. The Survey's hybrid program brings to light certain advantages of such a program, but also some hardheaded facts on the other side of the ledger.

The tremendous economic importance of hybrids produced from domesticated plants and animals (including corn, tomatoes, chickens, horses, cattle, and swine) has led to the rather popular misconception that all or at least most hybrids are vastly superior to their parents in both growth and physical characteristics. Unfortunately, however, most hybrids of all kinds of life are weak, maladjusted organisms which die before reaching maturity or are partially or completely sterile. Only those few hybrids which are definitely superior to the parents in one or more important traits such as rate of growth, size, or body form are said to exhibit "hybrid vigor."

In fishes, natural hybridization is much more frequent among fresh-water species than among marine species. Naturally occurring hybrid suckers, minnows, and sunfishes are quite common in Illinois waters.

Aquatic biologist William F. Childers and his co-workers at the Survey are conducting a study of hybridization among four species of sunfishes: the bluegill, the green sunfish, the redear sunfish, and the warmouth. All twelve possible hybrid combinations between these four parent species have been made by artificially introducing sperm from one species into small glass dishes containing ripe eggs from a different species. Large numbers of hybrids were produced by all crosses but in two the hybrids died during development. Of the ten hybrid combinations, two were normal (50 males to 50 females); four produced about 75 per cent males; two, 97 per cent males; one, 100 per cent males; and one, only 15 per cent males. Experiments indicate that the growth rates of the hybrids are very similar to those of the parent species, provided that every individual has plenty of room and food. In nature, however, the tremendous growth potentials of fish are rarely, if ever, realized.

In ponds stocked with one of the parent species, new generations of young result in a crowded condition and greatly reduced individual fish growth usually by the end of the second year. Some kinds of hybrid sunfishes do not reproduce under natural conditions. Ponds stocked only with these individuals would have a stable population and therefore the individual fish would grow faster because of greater amounts of food available to each individual. This would be ideal for stocking "pay fishing" lakes. But there is a hitch in this.

Hybrid sunfishes are much easier to capture by hook-and-line fishing than their parents. This was graphically recorded in 1958 by the Illinois Department of Conservation. Their counts show that a naturally produced bluegill × green sunfish hybrid population at the state lake in Lincoln Trails State Park was nearly eliminated in the first week of fishing. During the period from May 30 to September 29, fishermen caught and removed about 10,800 hybrids. Fifty per cent of these were caught the first day, and 82 per cent were caught in the first three days of fishing. This means that, where these hybrids are used in pay fishing lakes, catches per fisherman would need to be limited to prevent rapid extermination of the hybrid population.

Invasion Warning

At three points of the compass, three economic insects have become established within literally a stone's throw of Illinois. These are the cereal leaf beetle, the alfalfa weevil, and the southwestern corn borer, all potential serious threats to Illinois agriculture.

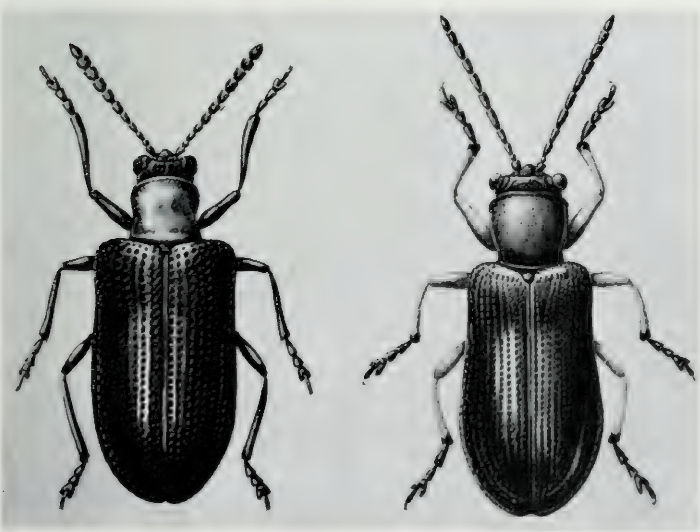
The cereal leaf beetle damages corn, oats, wheat, and barley. This tiny imported beetle, about ¼ inch long, is a native of Europe, was first discovered in the United States in 1960 in Michigan, and has now spread to two southern counties of Michigan and two adjacent counties in Indiana. The adults overwinter in straw, stalks, husks, and grain. In spring the adults move onto the green plants and eat the leaves. Dr. M. W. Sanderson, the Survey's beetle specialist, points out that this cereal leaf beetle is remarkably similar to quite a number of native species which are non-economic. Great care must therefore be taken to verify the identification of any beetles suspected of being this species. If native beetles were mistakenly identified as being the cereal leaf beetle this could trigger expensive and unneeded quarantines and control activities. On the other hand, not recognizing the beetle could result in its effecting a greater degree of dispersal than might otherwise be the case.

The alfalfa weevil, about ⅛ inch long, attacks the "queen of the forage crops," often completely destroying the first cuttings and delaying the growth of the second cutting of alfalfa. This devastating European immigrant, introduced into the United States more than 60 years ago and now abundant throughout the western states and found in the East from Massachusetts to Alabama, is known to be as close to Illinois as mid-Kentucky. Major damage to growing crops is caused by the greenish, soft, legless larvae which hatch in the spring. The early season feeding on the tips, leaves, and buds of alfalfa often destroys the feed value of the hay crop or prevents valuable seed production.

The southwestern corn borer, a small moth about ½ inch long, has caused tremendous damage to corn in the Southwest. It is a native of Mexico and entered the United States about 1913. By 1950 it had spread into Arizona, New Mexico, Texas, Oklahoma, Colorado, Kansas, and Nebraska. Since then it has moved into Louisiana, Mississippi, Arkansas, Tennessee, and Missouri, where it now occurs in the boot heel just across the river from southern Illinois.

The little whitish caterpillar, about 1 inch long, with dark brown spots, feeds chiefly on corn but also attacks several other grass crops including sorghum. Damage to corn is evidenced by twisting of the stalks and stunting, often accompanied by stalk enlargement near the ground. The borer also girdles the stalk internally, weakening it so that it blows over easily. In heavily infested fields, as high as 100 per cent of the stalks may contain borers.

Comparison museum specimens of these and other economic species not at present in the state have been secured for the Survey's reference collection to insure the



The spiderwort beetle (left), one of many Illinois species which resembles the cereal leaf beetle (right). (Drawings by Alice Ann Prickett.)

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positive identification of suspected catches in the surveys conducted to detect the possible occurrence of these species in Illinois.*

Short of Wind?

There has been considerable speculation as to how many respirations or breaths per minute birds need during the extreme physical activity of flying. While tracking mallard ducks from impulses given out by a minute radio transmitter taped to the bird, Survey wildlife investigators discovered that the transmitter was also radioing back impulses which represented rate of respiration. They found that the average number of respirations was 14 per minute for a resting duck (14 to 20 per minute is normal for a resting human) but that at normal flight (about 40 miles per hour) the duck's respiration went up to 96 per minute. Survey scientists R. D. Lord, F. C. Bellrose, and W. C. Cochran report: "The respirations of the resting duck show a quick inhalation taking approximately 1.5 seconds and a gradual exhalation taking approximately 3 seconds. In contrast, the respirations of the flying duck show a quick exhalation, interrupted by a wing beat and an immediate inhalation, both taking approximately 0.4 second. The bird then apparently holds its breath for approximately 0.4 second, interrupted by a wing beat, before exhaling and inhaling again."

* A single larva of the southwestern corn borer was found in corn stalks at Urbandale, Alexander County, Illinois, on March 29, 1963, by Survey entomologists J. H. Bigger and H. B. Petty.

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The Illinois

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MAY, 1963

Chigger Warning

Summertime is also chigger time in Illinois. The smallest native ectoparasite that bothers man in our state, the chigger is many times smaller than the head of a pin and even slightly smaller than the period at the end of this printed sentence. Birds and reptiles are the natural hosts of chiggers, but man can also be attacked.

In the Midwest, chiggers do not transmit disease-causing organisms. By their feeding, however, they produce a persistent itching, or dermatitis, called trombiculosis. Chiggers do not feed on blood. Instead they suck up partially dissolved skin cells that are digested by salivary fluids injected by the feeding chigger into the skin of the vertebrate host. The itching sensation, an allergic reaction to the saliva secreted by the chiggers, may continue many days after the chigger is gone.

Often called itch mites or red bugs in the South, chiggers are the larval or youngest stage of mites belonging to the family Tromibiculidae. In the later nymphal and adult stages, these mites probably feed on insect eggs and tiny arthropods. Of the more than 40 species of chiggers that occur in Illinois, Survey chigger expert L. J. Stannard finds that only one, called *Trombicula alfreddugesi,* is troublesome to man and occasionally to domestic livestock.

Preventive measures are considered the best protection against chiggers. Survey entomologist W. N. Bruce recommends that commercial repellants containing benzol benzoate or diethyl toluamide be rubbed on the feet and legs, under the belt line, and around the groin each day before going into fields or woods. A solution containing one part benzol benzoate in nine parts of light mineral oil is particularly effective for this purpose and can be easily prepared. Taken at certain doses, drugs used for some other human allergies can also alleviate the itching caused by chigger bites.

Inclusive dates when chiggers are likely to be active in various parts of Illinois. They are especially abundant around bramble patches.

Underground Approach

People concerned with the control of Dutch elm disease have speculated for 30 years about the relative importance of root grafts as a means of local spread of the disease. The existence of natural root unions between neighboring elm trees has often been demonstrated by the use of

dyes and poisons. Studies during the past two years by Survey plant pathologists E. B. Himelick and Dan Neely now indicate that the Dutch elm disease fungus readily passes through these natural root unions.

Six Illinois cities with comprehensive disease control programs were selected for study in 1962. After combining the data obtained in the six municipalities, Drs. Himelick and Neely found a definite relationship between the number of adjacent tree infections and the spacing distance between elms. Ninety-three per cent of all adjacent tree infections found were within 30 feet of a previously diseased tree. Few infections occurred between trees 30 feet or more apart. Spread of the disease through root grafts was most frequent in those cities where a large portion of the elms were closely spaced. In one of the communities, the loss resulting from root transmission of the fungus was found to be slightly higher than loss resulting from bark beetle transmission.

Sanitation and spraying, the conventional methods for controlling the spread of Dutch elm disease by insect vectors, have no effect on preventing fungus movement through the root systems of the trees. Mechanical trenching is the only presently known method of breaking root grafts; however, the cost of this operation and the presence of streets, sidewalks, and underground pipes and cables limit the amount of trenching which can be done.

The Survey's preliminary studies of the chemical soil sterilant Vapam suggest that it may provide a control measure where root grafts are involved. When injected into the soil, Vapam effectively kills short sections of elm roots to a depth of 24 inches. Current results indicate that Vapam's root-killing action may prevent fungus transmission through root unions of diseased and healthy trees without injury to the healthy tree. This chemical treatment is less expensive than the trenching machine operation and causes less damage to private and parkway lawn areas. Usually the chemical kills only a small circle of grass (three to six inches in diameter) around each point of injection.

Second Chance

Before European man introduced the iron plowshare and broke the prairie sod, then cut ditches that carried away the water from swamp and swale, the northern half of Illinois was noted for its tremendous "Grand Prairie" of waving bluestem grass and a myriad of beautiful prairie plants. Before Chicago burgeoned, the lower end of Michigan was a mixture of sand dunes and lake bottom prairies left on the heels of the last Ice Age. Now both of these great natural scenes are gone from Illinois. Left are only a few small remnants, highly prized by naturalists and scientists trying to gain some idea of what the native plants and animals were once like in this state. Akin to these are two almost natural areas now being considered as possible national parks in other states.

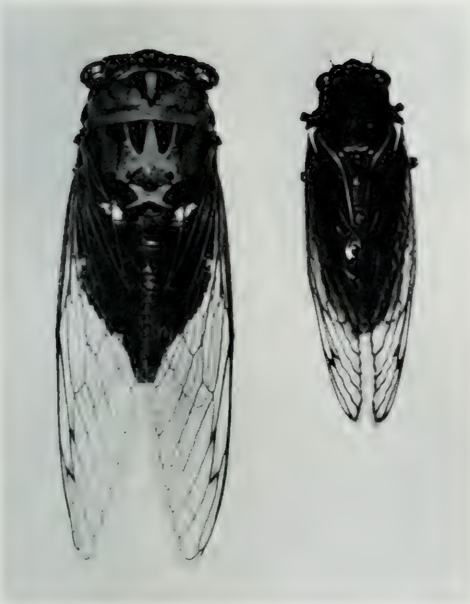
The proposed Indiana Dunes National Park, near Tremont, Indiana (30 miles east of Harvey, Illinois), contains fine and large samples of the type of country and life which once existed where Chicago now is, represented in Illinois only by the small area at Illinois Beach State Park near Zion, and the remarkable but all too small areas in the Cook County Forest Preserve.

North of Manhattan, Kansas (175 miles west of Quincy, Illinois), one of the last large natural areas of tall grass prairie has been proposed as the Prairie National Park. This is a marvelous tract, typical of much of the tall grass prairie which once spread across 400,000 square miles from the central Great Plains across central Illinois and just into Indiana. Studies in this area will enable natural scientists to unravel biological secrets about prairie grassland life which can no longer be done in Illinois.

By supporting bills for the establishment of these two national parks Illinoisans have a second chance to preserve areas representing the now virtually vanished Illinois landscapes which were traversed and described long ago by travelers such as Father Hennepin and naturalists such as Illinois' own Robert Kennicott.

The Periodical Cicada

This is the year of the cicada. Both a



The smaller, darker periodical cicada (right) measures 1½ inches from head to end of wingtips; the commoner dog-day cicada (left) which appears every year, later in the season than the periodical cicada is about 2 inches long. (Photo by Wilmer Zehr.)

17-year and a 13-year brood of the periodical cicada will appear simultaneously in Illinois in May and June. Often erroneously called locust, periodical cicadas sing in rhythmic unison often approaching a deafening roar. They are predominantly black, with amber-colored wing membranes, and are slighly smaller than the dog-day cicadas which appear every year and have almost colorless wing membranes and green markings on the head and thorax. Although not documented, it is calculated that the last time these 17- and 13-year broods appeared together in our state was in 1742 when Illinois was under French rule. This year's double feature of cicadas is the first time these two broods will have re-emerged jointly in Illinois since it has been an American state.

The 17-year brood, designated as Brood III, will appear in Champaign, Fulton, Hancock, McDonough, Mason, and Warren counties. The 13-year brood, designated as Brood XXIII, will appear in Alexander, Crawford, Edwards, Gallatin, Hardin, Jackson, Jasper, Jefferson, Johnson, Lawrence, Macoupin, Madison, Marion, Perry, Pike, Pulaski, Randolph, Richland, St. Clair, Scott, Union, Wabash, Washington, Wayne, White, and Williamson counties.

Survey staff members have kept long vigilance on our cicada populations. As early as 1898, Dr. S. A. Forbes, then Chief of the Survey, collected many of the records of Brood XXIII. Recent studies by Dr. T. E. Moore, formerly of the Survey, indicate there are six species of cicada involved in the emergence. Three of these species spend 17 years as subterranean nymphs; the other half spend 13 years feeding on roots underground. The adults live only a few weeks after emerging from the long underground nymph stage.

These 13- and 17-year broods will include a particularly large number of individuals, and probably will cause considerable economic damage to trees, nursery stock, and orchards. Damage is largely the result of egg-laying by the adult females whose sawlike ovipositors make slits in the terminal twigs of woody plants causing a condition similar to girdling. When the eggs hatch, the nymphs drop to the ground, burrow in, and begin their 13- or 17-year-long meal on the roots of the tree. In the past, root damage in natural forests has not been detected. However, in a few instances extensive damage has occurred in orchards.

In this "year of the cicada," scientists from Michigan, the Chicago Natural History Museum, and the Natural History Survey will be studying these two particular broods to learn more about the exact situations in which they occur and the significance of the simultaneous appearance of the three different species in each of these two broods. Members of the Survey will be concentrating on taking records of the distribution of these periodical cicadas. Also, scientists from Canada plan to study the Illinois broods to learn more about a fungus disease which causes the death of adult cicadas. Illinois residents noticing aggregations of cicadas in May and June are urged to notify Survey entomologists.

Make Mine Muskrat

Although Illinois was once fertile pelt-harvesting ground for early French

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trapper-explorers, today's average trapper's income indicates that trapping is now more of a sport or hobby than a source of revenue. Despite comparatively low prices, the fur resource is still worth approximately one-half million dollars annually to the trappers of this state.

Nine species are considered to comprise the wild fur resource in Illinois. These include the mink, beaver, raccoon, skunk, muskrat, weasel, red fox, grey fox, and opossum.

Declining prices of furs, relatively higher wages, and adequate employment opportunities in other fields have all served to reduce the importance of trapping in recent years. The number of licensed trappers in the state has dropped steadily since the end of World War II. A total of 30,949 trappers bought licenses for the 1946–47 season, but by the 1953–54 season there were only 11,251 licensed trappers in the state, and by the 1960–61 season only 4,355. These figures do not, of course, include owners actually residing on, or bona fide tenants of, farm lands and their children, who may trap such lands without purchasing a license.

Illinois is one of the few states which does not obtain figures on the numbers of each species of furbearer harvested each year. The greatly reduced number of trappers and changes in the fur market also make estimating current populations difficult. In all probability, however, numbers of most furbearers in Illinois are now well above those of the early years of this century.

VALUE OF FURBEARERS SOLD IN ILLINOIS

(no grey fox sales reported)

Species	*No. Taken*	*Average Price*	*Total Value*
muskrat	383,600	$ .70	$268,520
mink	16,800	9.44	158,592
raccoon	30,300	1.41	42,723
beaver	1,100	7.86	8,646
red fox	4,500	.96	3,600
opossum	5,700	.53	3,021
skunk	900	.69	621
weasel	200	.55	110
			$485,833

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JUNE 1963

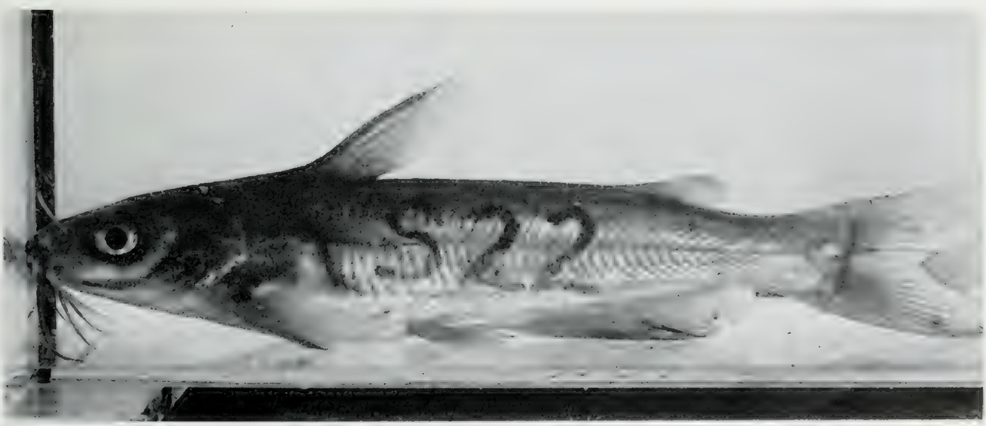
We Have Your Number

To improve fishing we need to know more about the fish themselves, especially their habits in the wild: how long they live, how much they move from place to place, their reactions when subjected to pollution, and so forth. Lack of a successful method for marking individual fish has long stymied much of this work. Fisheries biologists have used fin clipping or tags. The tags are unreliable at best, and too heavy for small fish. Fin clipping has only a few numerical possibilities and cannot be used individually for large numbers of fish. Too often, branding with a red-hot wire causes extensive damage and death of the fish.

In an attempt to avoid the damaging effects of high temperatures on underlying tissues, R. Weldon Larimore and his Survey co-workers have recently used a high-frequency electrical spark to mark fish. Produced by an instrument called a hyfrecator (used in medical practices to cauterize human tissues and remove skin growths), the spark can be regulated in intensity to cut through the skin and produce a clean mark of scar tissue, which does not become infected, or simply to char the surface tissues and alter the distribution of skin pigments. Applied to the skin of fish with a stylus-like electrode, the high-frequency spark can be used to create a limitless variety of identification marks.

Our first marking experiments of channel catfish caused no damage to the fish but the numbers were recognizable for only four months. With continued improvising, we now have marked fish whose numbers are discernible after nine months. During the winter some of these fish were killed by adverse conditions under ice. After the ice melted in the spring, the markings were found to be still very distinct on the partially decomposed fish.

This new marking technique is espe-



Eight-inch channel catfish showing its identification number. This number is approximately ¾ inch high and is nine months old.

cially good on scaleless fish such as catfish and on fish with very small scales such as trout. It produces a mark of only short duration on fish with large scales, but further investigation may overcome this limitation. Properly applied, such marking causes no harm to the fish and eliminates causes of mortality sometimes associated with tagging and fin clipping.

Pesticides and Wildlife

The Illinois Natural History Survey is charged by law to make recommendations for the increase and welfare of our renewable natural resources; these include the game, fish, and other wild species which are part of the natural recreational resources of the state. The Survey is further charged, in other articles of the same statute, to give to the people of Illinois the most effective methods known for protecting their property from insect damage.

Realizing the potential conflict in recommendations made in response to these two responsibilities, the Survey organized a Wildlife-Pesticide Coordination Committee whose aim is to reduce pesticide hazards to wildlife to the minimum that is consistent with sound control needs. The Committee consists of five section heads, representing the fields of economic entomology, aquatic biology, game management, plant pathology, and natural area studies. At its first meeting, held on April 2, 1963, the Committee reviewed the more critical recommendations being considered by each section, discussed various interactions of these bearing on wildlife-pesticide problems, and agreed upon changes in recommendations along the following lines:

(1) Recommending the use of formulations least toxic to wildlife which will give satisfactory control; for example, the substitution of methoxychlor DDT in the spring dormant spray for control of insect vectors of Dutch elm disease.

(2) Recommending that soil insecticides be disked in immediately upon application, both as a precaution against wastage of insecticide and as a preventive against wildlife losses, especially pollution to streams.

(3) Accompanying pesticide recommendations with appropriate warning concerning hazards to wildlife.

(4) In recommendations of game management practices, avoiding plantings which are alternate hosts of diseases or favorite hosts or living quarters for economic insects.

In addition to these immediate suggestions, the Committee approved the following long-term aims concerning the scientific investigations of the Survey in the wildlife-pesticide area:

(1) To continue the search for parasites or disease organisms of pest insects in an effort to reduce the populations of as many species as possible to a noneconomic level.

(2) To investigate other nonchemical techniques for reducing or eliminating the populations of pest species. This would include the adaptation of sterilization techniques for use under Illinois conditions, developing new techniques in cultural practices, the search for crop varieties and strains which are either resistant to or tolerant of insect damage, and the manipulation of soil biochemistry.

(3) To improve both the detail and accuracy of surveys of economic insects to the end that more and more areas of low infestation could be detected and left untreated.

(4) To investigate the effect of various control programs on populations of terrestrial and aquatic wildlife.

(5) To locate local natural areas of unusual scientific significance, especially from the standpoint of the preservation of rare species of plants and animals, and, if at all possible, have these designated as areas which would not be treated with pesticides except under conditions of gravest emergency.

It must be emphasized that, even if we had ample funds to follow all of these lines of investigation vigorously (which we do not have at present) progress would necessarily be slow, because the painstaking research needed to make advances in these areas cannot be hastened more than insect life histories and progress

in knowledge will allow. Nevertheless, we feel that by scrutinizing current recommendations diligently and by pressing for more and more methods of insect and disease control by means which are harmless to wildlife, the wildlife-pesticide problems can eventually be eliminated.—WILDLIFE-PESTICIDE COORDINATION COMMITTEE (G. W. Bennett, J. C. Carter, G. C. Decker, T. G. Scott, H. H. Ross, Chairman).

Hay Makers

Last summer did your lawn have patches of brown, dead turf? If so, you had a visitation from sod webworms. These are the larvae or caterpillars of several species of moths belonging to the genus *Crambus*. Survey entomologist Dr. H. B. Cunningham says that these little fellows feed on Illinois lawns every year, often causing only imperceptible damage, but occasionally occurring in great numbers and destroying large areas of lawn grasses.

The moths are small, greyish buff, ½ to 1 inch long, and fly erratically over the lawn about dusk. The moths themselves do not cause any injury. They drop their eggs into the crowns of the grass. These eggs hatch into creamy white caterpillars having a dark brown head and brown spots on their bodies, often attaining a length of 1 inch or more. These caterpillars make a tunnel into the ground, in which they hide during the day. At night they emerge from their tunnels, bite off blades of grass near their holes, pull the grass into the tunnels after them and eat it. At times of heavy infestation all that is left of the grass is the mat of dead "hay" always present under the green blades.

Impending damage by webworms may be indicated by large numbers of the moths hovering over the lawn. Unusually large numbers of birds in search of the caterpillars may also indicate webworms feeding on a lawn. However, the most positive evidence of webworm presence is the appearance of irregular brown spots of dead grass resulting from webworm feeding. When such irregular areas of brown grass appear, control measures should be undertaken immediately.

Webworm damage to lawns usually occurs from July through October. When damage has been severe and moths have been abundant in the late fall of the previous year, the caterpillars may overwinter and cause damage in May even before the first generation moths appear. When lawns are well fertilized and watered, grass growth is frequently rapid enough to withstand a considerable infestation of webworms without appreciable damage. Damage is usually most extensive under drought conditions.

If your lawn is threatened, write to the Survey for up-to-date control methods.

Rabid "Striped Kitties"

Only during a rabies outbreak when

Full-grown sod webworm larva among dead grass. The entrance to its hideaway tunnel is the round, black opening at the right.

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domestic dogs are bitten by rabid skunks, as happened in northeastern Illinois a decade ago, are we reminded that these "striped kitties" provide one of the natural reservoirs of this disease. The percentage of wild skunks which are rabid is very low, and varies from year to year. Thus, numbers of reported rabid skunks declined from 94 in 1961 to 72 in 1962.

Recent studies of Survey wildlifer Dr. Glen C. Sanderson have sought factors for determining the susceptibility of skunks to rabies. The best correlation concerns their physical condition. During the winter, skunks often lose one-third to one-half of their autumn body weight. Both males and females have the lowest body-weight to body-length ratios in March. Male skunks begin to recover weight lost during winter in April, but the females do not gain rapidly until after their young have been weaned in July. Because the incidence of reported cases of rabies in striped skunks usually reaches a peak in April or May and because most of the infected skunks at that season are females, there is good reason to believe that poor physical condition coupled with the stresses of pregnancy and lactation greatly increase the susceptibility of skunks to rabies.

On a regional basis, the incidence of rabies among skunks appears to be correlated also with the relative density of skunks. In the past five years, two to five times as many rabid skunks were reported in Iowa as in Illinois. During 1962, the Illinois Rural Letter Carriers Association and the Illinois State Police cooperated in keeping counts of skunks killed along roads, while similar censuses were being conducted in Iowa. Rural mail carriers and state police in Iowa reported seeing 35 and 65 per cent more skunks per 1,000 miles traveled on the census days than their respective counterparts in Illinois.

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The Illinois

NATURAL HISTORY SURVEY REPORTS

JULY 1963, NO. 9

Rat Walkie-Talkie

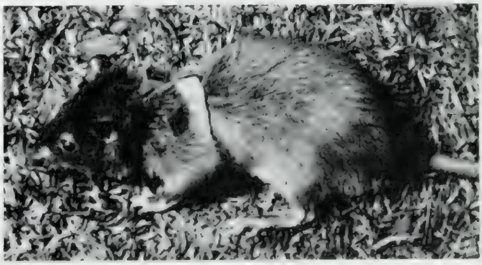
Do rats suffer from headaches? If so they may have a case of one of Illinois' lesser known but nonetheless widespread diseases called leptospirosis. In domestic and wild animals, this bacterial disease may cause abortion, poor condition, and sometimes death. In humans it causes flu-like symptoms of high fever and headache. In some small wild animals, notably mice and rats, the disease produces no visible symptoms; whether it gives them headaches is open to speculation. The disease is spread from animal to animal chiefly through contamination of food and water through urine. Humans can contract it by swimming in contaminated water. Among humans this disease is much more prevalent in the tropics, where rats are thought to be the principal carriers.

Survey wildlife specialist, Dr. Glen C. Sanderson, has just returned from Kuala Lumpur, Malaya, where he spent some time working on rats and leptospirosis at the invitation of the Army Medical Research Unit and the Malayan Institute for Medical Research. Scientists at this Institute had learned much about the relationship between rats and leptospirosis, but they lacked a good method for tracking rats at night and locating them in hiding places during the day. This Dr. Sanderson provided in the form of miniature radios, developed by the Survey and the U. of I. Electrical Engineering Department. These radios can be attached to animals, the animals then released, and their movements followed by radio-tracking receivers. In this cooperative study, medical research found a new tool for its work and Dr. Sanderson learned a great deal about rats, their daily habits, and the influence this has on their potential for spreading diseases.

In addition to their role in spreading leptospirosis, rats and their fleas are the chief vectors of bubonic plague. In the United States plague is known to be endemic only in isolated wild rodent populations in the West. Every once in a while, however, we get a scare when danger signs are found in thickly populated areas. This happened when a plague-infected rat was captured this winter in the San Francisco Bay area. This is another reason that it pays us to keep our knowledge of rats up to date.

Insect Economics

After April 15 most folks can lay aside their pencils and adding machines with a sigh of relief. Not so the economic entomologist. This is when figures become available for crop yields and prices for the previous year's harvest and for his own treated and untreated plots. Armed with



Rat with radio. The miniature sending set is embedded in the collar which encircles the rat just behind the shoulder. The set will transmit signals for two weeks.

this data and information concerning who treated what crop for what pest, he can obtain a reliable estimate of the savings that resulted from the use of his control recommendations.

As in years past, survey entomologists Dr. H. B. Petty and Dr. Stevenson B. Moore and their associates assembled and summarized data on the extent and estimated value of insect control measures applied to control insect pests of Illinois crops during 1962. It is difficult to obtain figures on the effect of insecticides on fruit crops. Illinois' principal fruit crops, apples and peaches, are dependent on a coordinated spray program aimed at controlling bacterial and fungus diseases in addition to injurious insects; elimination of either program would result in a crop of little more than culls. The most reliable figures can be obtained for field crops through information supplied to Survey entomologists chiefly by Illinois farm advisors. The following table lists the estimated profit over and above costs resulting from insecticide treatments on Illinois field crops in 1962.

Crop and Insect	*Acres Treated*	*Estimated Profit*
Clover and alfalfa		
Cloverleaf weevil	8,154	$ 12,231
Potato leafhopper	12,292	24,584
Meadow spittlebug	9,356	9,356
Sweet clover weevil	17,789	142,312
Pea aphid	11,585	17,378
Corn		
Soil treatment	3,505,122	14,020,488
Cutworm	172,081	860,405
Corn borer	129,226	516,904
General		
Grasshopper	1,472,645	6,885,872
True armyworm	59,901	299,505
Total	5,398,151	$22,789,035

In another way Survey entomologists save the Illinois farmer at least an equal amount of money. Through their weekly survey of the abundance of injurious insects throughout the state, these men provide farmers in pertinent areas with firm assurance that certain crops *do not* need to be sprayed because insect pests in their regions are not sufficiently abundant for control measures to be profitable. The abundance of these pests is intimately associated with weather conditions during all stages of their life histories. Because weather is highly irregular over the state, certain kinds of pests may be abundant in one part of Illinois and scarce in others.

It costs about $1.50 per acre to treat field crops with one average insecticide treatment. Following recommendations in the weekly "Insect Survey Bulletin," in 1962 sprays were not applied to field crops in whole sections of Illinois. It is virtually impossible to figure the cash savings to the farmer through these preventive recommendations in areas of low pest populations, but undoubtedly it was equal to or greater than the 20 million dollars which they made on those acreages to which sprays were applied.

Cedar-Apples

Have you ever noticed what looked like small green apples on the twigs and branches of your junipers? They are often inconspicuous until the spring of the year when, following a warm rain, orange-colored tendrils spring up from these "apples" and turn them into ephemeral brightly rayed ornaments. These "apples" are really galls formed by a rust and the orange-colored tendrils shed masses of rust spores. These rust organisms have two hosts; one is a juniper and the other a species of either apple or hawthorn. They have alternating generations on these two. The galls, though temporarily pretty, cause serious damage to the junipers, and susceptible trees must be sprayed with a fungicide to protect them from this pest.

For several years Survey plant pathologists, Dr. E. B. Himelick and Dr. Dan Neely, with the cooperation of the Morton Arboretum, have made careful observations of about seventy forms or varieties of junipers grown in Illinois to investigate differences in their susceptibility to the attack of these disease organisms. The pathologists discovered that certain species and varieties of junipers are attacked very badly by these rust diseases whereas others are almost completely resistant to the cedar-apple rusts. Home owners and landscape architects may obtain lists of these resistant junipers on request.

The Changing Scene

One of the great values of an institution that has been in existence for a long period of time is that it can keep certain areas under almost continuous surveillance and study natural and man-induced environmental changes over a many-year period.

An illustration of such intensive and long-term study is provided by a recent Survey reinvestigation of the streams of Champaign County in east-central Illinois. In 1899 and a few years before and after, the Survey's first Chief, Dr. S. A. Forbes, and his associate, R. E. Richardson, conducted an extensive study of Champaign County streams and their fishes. In 1928 and 1929, Survey biologists Dr. D. H. Thompson and F. D. Hunt made an equally thorough survey, aimed at discerning the changes that had occurred in Champaign County waters during the 30-year period following the Forbes and Richardson survey. Their study, published in 1930, was widely acclaimed because of the many important generalizations and inferences made possible by the thoroughness of the two investigations.

When a second 30-year period had drawn to a close, current Survey staff members, Drs. R. Weldon Larimore and Philip W. Smith, embarked on a third investigation and revisited nearly all the sites that had been studied in previous surveys. The three intensive surveys, supplemented by occasional observations by other Survey staff members, personnel of the University of Illinois, and local naturalists and fishermen, thus provide an enormous amount of data on changes in streams and fishes for a period of more than 60 years.

During the period of study, Champaign County was converted from predominantly prairie marsh to well-drained farmland. The effects of draining, dredging, and cultivation on the marshes, streams, and water table almost defy the imagination. In recent years, urbanization, industrialization, and the use of fertilizers also have had a profound effect upon our aquatic life. Despite these changes in the landscape, 74 different kinds of fishes still occur in the county, and some of them appear to be present in about the same numbers and same places that they were 60 years ago.

A few kinds of fishes have not been able to tolerate the changes and have disappeared. As they left, other kinds have come in to replace them. A number of species have decreased greatly in abundance; others have increased. Certain kinds of fishes have proven to be extremely sensitive to changes in stream conditions,

Seining party on the Sangamon River. Dr. Smith, upstream, is agitating the stream bottom. This dislodges darters, madtoms, and other small fish which swim down into the bag of the seine.

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and populations of these kinds are of especial value in indicating the degree of pollution and the type of ecological succession, and also in reflecting former conditions of the environment. Anglers will be pleased to learn that species such as the rock bass, smallmouth bass, and some of the redhorses are more abundant now than formerly, but disappointed to hear that crappies, warmouth, and certain suckers are less common.

Several important principles regarding abundance and occurrence of fishes have been realized through this long-term study of Champaign County. For example, it is now known that the number of individual fishes is greater upstream than downstream, but that the average size of individuals is considerably greater downstream. Thus, barring such unusual circumstances as pollution, the actual weight of fish flesh per unit of water is almost constant. There is also evidence that the amount of fish flesh is greater in watersheds of high fertility than in areas where the soil is poor.

Important information on the effects of pollution and enrichment of waters was made possible by study of streams that were unpolluted in the early periods of the study and now are polluted in varying degrees.

Details of the changes in our streams and fishes and other information concerning long-term changes in aquatic environments are given in a recently published Survey Bulletin, "The Fishes of Champaign County, Illinois, as Affected by 60 Years of Stream Changes." (Available from the Survey at 50 cents per copy.)

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NATURAL HISTORY SURVEY REPORTS

AUGUST 1963 NO. 16

Uninvited Guests

Have you been bothered at home or more particularly at picnics by a small, shiny black beetle which burrowed into buns, potato salad, or plunged into the pickle jar? These uninvited guests are picnic beetles, known to entomologists by the scientific name *Glischrochilus quadrimaculatus.* These become extremely annoying by invading exposed foods in back yards, roadside fruit and vegetable stands, and food processing plants.

Thirty years ago and before, this beetle was rarely seen around dwellings. During the past two decades it has either become more abundant, or has changed its habits and is now one of our common midsummer picnic and household nuisances.

About ¼ inch long with four yellowish-orange spots on its outermost wings, the picnic beetle overwinters as an adult and in the spring produces a single generation on decomposing food material in the soil. Adults of the new generation appear in late June and July and feed on ripe, damaged, and decomposing plant materials the remainder of the season. The adults are also attracted to exposed prepared food in outdoor areas and they congregate on screen doors, attracted there by the odors of cooking food.

Studies by Survey entomologist Dr. William H. Luckmann indicate that the picnic beetles feed chiefly on rotting tissues, originally injured by other animals or by weather. They are especially fond of the rotting material in tunnels made by larvae of the corn borer. However, in undamaged silking corn ears and ripe raspberries the picnic beetle appears to be a primary invader. Moist, fermenting pollen on the corn silk may possibly attract the beetle to the silking ear. In raspberries, the first elements of decomposition after ripening may provide the attraction.

The picnic beetle in and around vegetable and fruit stands can be controlled with several insecticides; homeowners can reduce beetle numbers by using various sprays or baits (details sent on request).

For Outdoors Enthusiasts

Driving across much of Illinois, passing field after field of waving corn and satin-green soybeans, the naturalist might think that the State had few areas of unusual interest to biologists and scientists. This idea is dispelled by the Survey's just-published Biological Notes No. 50, "Some Unusual Natural Areas in Illinois and a Few of Their Plants," by Survey botanist Dr. R. A. Evers. The article, written especially for naturalists and teachers, describes

Picnic beetles feeding on decayed plant material in stalk. Note the spots and the clubbed antennae or feelers. (Photo by H. B. Petty.)

24 areas, each unusual because of some rare or unusual plant or set of plants. For example, it mentions Lusk Creek Canyon northeast of Eddyville, one of the very few Illinois localities where a certain rare clubmoss has been found. Here a patch of this clubmoss grows high on a sandstone cliff forming the rim of Lusk Creek Canyon.

There is note of the only good Illinois growth of trees of the short-leaf pine, growing on the rocky upper slopes of the bluffs of the Mississippi River in Pine Hills near Wolf Lake. Many of the unusual items were once not unusual but are gradually disappearing. For example, in Fort Massac State Park east of Metropolis is one of the last Illinois stands of the southern willow oak, recognized by its willow-like leaves and typically oak acorns. Once widespread in the bottom lands of extreme southern Illinois, most examples of this oak have been cut or removed and the species is now an Illinois rarity. Illinois Beach State Park north of Waukegan gets its share of notice for its patches of a wild purple phlox and the unique sand willows and junipers. Even that most commonplace of the commonplace, the railroad right-of-way, harbors unusual features. An excellent illustration is the Illinois Central right-of-way area between Mason and Alma, where grows a remarkable stand of big bluestem prairie with its galaxy of true prairie plants. Single copies of this publication will be distributed free on request.

Pesticide Precautions

Stressing the fact that an overdose of many pesticides may cause illness or death to humans, pets, and other species of plants and animals which are not the target species, the Natural History Survey has cooperated with the Chemical Safety Committee of the University of Illinois College of Agriculture in preparing a two-page list of suggestions called "Safe Use of Pesticides."

Three types of precautions are stressed, one set for handling pesticide concentrates, another for using household pesticides, and another for applying pesticides. Some of these precautions are so obvious that they would seem unnecessary, such as "Do not leave mothballs where children can find them. Mothballs resemble candy," and "Do not store pesticides . . . in the medicine cabinet." Yet failure to follow exactly these suggestions has led to the death of unsuspecting children and adults. If you are applying pesticides to control insects, rodents, weeds, etc., you should secure and read this list of precautions. We will be glad to send a copy on request.

Nimrods' Delight

What causes ups and downs in the abundance of pheasants and quail? Why do they prosper in this area and not in another? If we knew the answers to these questions we would have a chance to modify causes of population declines or conditions leading to poor game production. Counting the number of birds shot during the hunting season gives some idea of the results of all these causes, but it does not tell you why this result is what it is. To get at the "why" requires painstaking work throughout the whole year by highly trained game scientists, periodically aided by the keen eyes and strong backs of crews of younger helpers. Trying to unravel some of these mysteries of game numbers is a big part of the Natural History Survey's game research program. Dr. John E. Warnock and G. Blair Joselyn follow especially the fate of the State's pheasants; Jack Ellis is especially concerned with quail.

You may have seen pheasants or quail with large number tags on their backs. This is a trick the Survey biologists have found extremely useful in studying pheasant and quail populations. Counting the total number of birds in an area at different times gives only a partial knowledge of what is happening in the bird population. It doesn't tell you whether the birds are moving from area to area or whether you are counting the same bird more than once when you flush the birds in a long counting stretch across large fields or roadsides. Marking individual nests is easy; all you need to do is drive in a stake with a number near the nest and note its position. Marking the birds themselves is not so easy. Feather clipping might hinder

their flight so that marked birds would be more subject to an untimely death and hence not give an accurate idea of what happened to an average bird. After many trials and observations, two Survey game scientists designed a large tag which can be strapped on the bird and which seems to offer minimum hindrance to its normal movements. An observer can identify these birds at a considerable distance with a spotting telescope.

In recent years, the Illinois acreage of hayfields (prime source of pheasant nesting) has decreased. In an attempt to offset the situation, the Survey has tried to develop improved pheasant nesting cover along secondary roads. Many of these roadsides usually are covered with short grasses or other vegetation which makes poor nesting cover for pheasants. In selected plots this vegetation was scraped off and the areas seeded to various combinations of grasses and legumes. Some of the cover has proven remarkably successful. Brome grass in particular seems to be just to the pheasant hen's liking for nesting. By keeping records of tagged hens, our biologists discovered that many of the nests along the roadsides were established by hens whose earlier nests were destroyed by hay-mowing in adjacent fields. The success of these roadside strips to date indicates that managed nesting cover along the extensive secondary road system in the intensively farmed parts of Illinois may be instrumental in raising pheasant populations and providing greatly improved hunting. For widespread application, roadside maintenance practices, especially mowing, will need to be adjusted very carefully so as not to undo the benefits of the plantings. As the acreage of hay crops decreases in the northern half of Illinois, however, roadside manipulation may prove a highly efficient substitute for increased game production.

Pheasant showing back tag in position. These have proven remarkably durable and successful and apparently the birds don't mind. (Photo by Wilmer D. Zehr.)

Wheat in the Bin

Every year billions of bushels of corn, wheat, oats, and soybeans are stored in elevators and granaries throughout Illinois. The cash value of the stored crop at any one time may exceed a billion dollars.

Some of this crop will go into industrial processes such as making plastics. The rest will be fed to livestock or converted into bread, corn flakes, birthday cakes, and other things we like to eat. A hungry group of insects also likes to eat this stored grain. A dozen different kinds of beetles, the caterpillars of four or five different kinds of moths, and a group of tiny, rapidly reproducing mites — collectively called stored grain pests — are forever ready to invade granaries, elevators, and warehouses on farms or in towns and to begin feeding on unprotected grain. The rapidity with which these pests become established in untreated stored grain is remarkable, necessitating constant vigilance and often costly control or treatments by fumigation or insecticides. Survey entomologists Dr. Petty and Dr. Moore estimate that roughly one-half of the stored grain moving through the state is treated for insect pests, and that of the untreated grain, the insects get on the average from 5 per cent to 10 per cent.

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This month Dr. Ren Ishihara of the famous Sericultural Experiment Station in Tokyo, Japan, will be exploring with the Survey's Dr. John Kramer the possible use of a biological ally in attacking at least the beetle components of the stored grain pests. Dr. Ishihara, traveling under the auspices of the Food and Agriculture Organization of the United Nations, will be working at the Survey for several months investigating the habits and biological potential of a tiny unicellular animal called *Nosema* which is known to parasitize one of the beetles which becomes abundant in stored grain. The long journey from these laboratory cultures of *Nosema* to field applications may prove to be impractical, but these two scientists are starting the pioneering scientific studies needed to know whether this little one-celled animal has promise of being a significant aid in man's efforts to protect his food supply.

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SEPTEMBER 1963, NO. 11

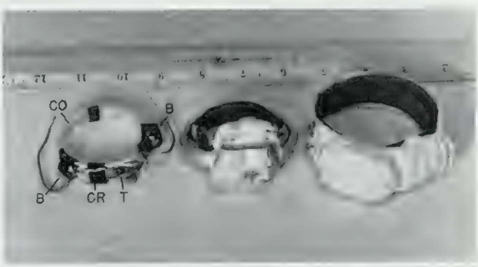
No Place to Hide

In response to inquiries concerning the miniature radios used in the "rat walkie-talkies" mentioned in the July number of these *Reports,* we take pleasure in giving a brief explanation of what they are. These radios are transmitting sets consisting of a crystal oscillator, a transistor, accessories including minute condensers and resistors, and an antenna. The set is powered by one or two small mercury batteries. The antenna runs around a plastic collar which holds the set on the animal. In the accompanying figure, the right-hand set shows the parts in place on the collar. The loose wires are the battery leads which are not connected until the set is ready to be put on the animal; connecting these battery leads turns the set on. Because the little radio will be exposed to weather and rough handling after it is on the animal, the electrical parts are first covered over with a flexible plastic substance, then this in turn is covered with epoxy, an extremely hard-setting glue. The plastic collar with its antenna is covered with waterproof plastic tape and has an adjustable collar of a neoprene-coated material on the inside. The battery leads are left sticking out close together so that, after the set is encased in its protective covering, these can be twisted together and soldered rapidly just before the set is put on the animal.

When the set is to be used, the animal is anaesthetized lightly (only persons who do not value fingers and pieces of skin try this with unanaesthetized animals). The ends of the inside flexible collar are then tightened and sewed to keep the set firmly in the desired position on the animal, and the animal released. The signal from the radio can be detected by a number of direction-finding receiving sets. By charting the changing directions of the sending set by the use of stationary or portable receivers, the path of the animal can be followed with great accuracy. In one instance a rat bearing a set was caught by a cat, and the cat tracked to its home. Of course it was really the radio that was tracked. The mystified owner allowed the investigators to claim the set, which was in working condition, and the rat, which was minus its head and one front leg.

The Illinois Dunesland

The plants and animals of any area, and the terrain itself, are the product of changes dating back thousands and millions of years. Glimpses into the history of these events not only give a perspective



Three miniature tracking radio transmitters. The one on the left shows the principal parts (*b*, batteries; *co*, collar with antenna; *cr*, crystal; *t*, transistors). The middle transmitter has the parts partially imbedded, the one on the right has them completely imbedded and ready for use. These also represent three types used on different sized animals.

as to how things became the way they are, but are also the basis for any attempted predictions concerning future living conditions. The Illinois Dunesland, a narrow strip of Lake Michigan beach extending from Waukegan northward, has an especially interesting history. This is outlined in the Natural History Survey's new Circular 49, "The Dunesland Heritage of Illinois," by Dr. H. H. Ross. Single copies may be obtained free on request.

The Watch at Home

Publicity given to persistent insect pests such as the face fly, the European corn borer, and the cereal leaf beetle, all accidentally introduced from other countries, may impart the impression that all our insect pests come from abroad. This is not so. Grasshoppers, the chinch bug, and the plum curculio are only a few of the native species which feed on crops planted by man. Other kinds of native insects which originally did not feed on cultivated crops may undergo a change in habits and start feeding on cultivated plants. Such an instance was one of the June beetles, which now feeds in considerable numbers on soybeans. Other native species seem to be just on the threshold of making this switch from a harmless member of the wild to a competitor for the crops that man plants.

Such a species is one of our native moths called *Simyra henrici,* known for nearly a century as a species feeding primarily on cattails and occasionally on smartweed, willow, or wild grasses growing in marshy areas. In 1954, 1955, 1957, 1959, and 1962, this species demonstrated its potential to damage corn, small grains, and cultivated grass crops. Natural History Survey entomologists became especially interested in this species in mid-1962 when its caterpillars were found in scant-to-moderate numbers in about 10 percent of all the corn fields in Illinois. This potential warrants an evaluation of its economic potentialities and any natural factors tending to restrain or control its rate of reproduction.

Like all moths and butterflies, *Simyra* has a life cycle consisting of the egg, caterpillar, pupa, and adult. The moths appear in late April or May, some emerging from overwintered cocoons and some arriving as migrants from the South. Each female deposits 1,000 to 2,000 eggs (as many as 1,000 in a single night). The eggs soon hatch and the life history, through caterpillar and pupa to the adult, is completed in 35 to 70 days, depending upon prevailing temperatures. In Illinois there are usually two generations a year.

This is a fantastic rate of reproduction.

The life history stages of *Simyra henrici.* From left to right are shown the minute eggs (highly magnified), the larva, and the adult moth.

If it went unchecked for 2 to 3 years, we would be literally knee-deep in *Simyra* caterpillars. In the laboratory, the caterpillars or larvae of this species thrive on corn, wheat, oats, canary grass, or even bluegrass, and it has at times developed on these crops under field conditions. Why then has it not become a major pest of these crops? At the moment Survey entomologist George C. Decker feels that we can only speculate on the answer to this question, but some of the available clues are fascinating.

At least a dozen species of minute parasitic flies and wasps prey on the larvae and pupae, and several seem to be generally distributed and abundant. They may be a dominant factor in the natural control of *Simyra,* but there is another possibility. At least four internal diseases of *Simyra* have been detected in the field, and at times they become so prevalent in laboratory cultures as to make continued rearing impossible until a thorough clean-up and a new start is made. The higher the temperature above 75° F., the higher the mortality due to diseases. This suggests that *Simyra,* which readily eats corn, has been reduced to the status of a cattail feeder because only under the cooling influence of an aquatic habitat can it consistently survive disease infection.

What appear to be the same pathogens are frequently found in armyworm caterpillars and here again the same temperature conditions prevail. Does *Simyra,* living on the cattails, maintain a reservoir of disease which makes it impossible for them to perpetuate their species on corn? Do they, by their love of corn and grain crops, spread infection which makes it difficult for the armyworm to survive and reproduce its kind in midsummer? Only diligent scientific research can produce the answers to these intriguing problems.

Fish Growth

The old expression "not eating enough to keep a bird alive" would be even more emphatic if the word "fish" were substituted for "bird." Fish are among the most adaptable of animals in surviving for long periods of time under starvation conditions. One of the very few animals that grow throughout their life, most fish can survive for a whole year on a semistarvation diet and then resume their growing as food becomes more readily available. If water temperatures are not too warm, some kinds of game fish may live up to three or four months with absolutely nothing to eat. Like humans under starvation conditions, the fish lives on its reserve fat and muscle tissue.

At times fish become sufficiently abundant in a lake or pond that they have available only a maintenance diet, in which case they do not add any new growth for an entire year. If the fish are overcrowded to a lesser degree, individual fish get only enough food to make a very small growth during the year, resulting in stunted populations. Because of the importance of fish growth to good fishing, Survey aquatic biologists have made special studies in this area of investigation.

In addition to being dependent upon food conditions, fish do not grow under low temperatures. In Illinois, fish growth virtually stops when the water temperature drops below about 50 or 60 degrees. Thus, in our Midwestern climate, none of our fish grow during the winter months. Physiological factors such as spawning may also retard growth, and add to the uncertainty about when certain species begin their annual growth. Some fish, like the blue gill, may have more than one period of growth during the same season. Their growth may begin when the water becomes warm in March or April, stop during spawning, and then resume. Some other fish, like the sexually mature crappie, do not begin the new year's growth until after their spawning period.

Most fish have their greatest increases in length during their first two years. After that, growth in length slows down and the fish becomes more chunky. Growth may be abnormally fast in fish stocked in a new lake that has abundant food and few fish to use it.

Because of these variables involved in fish growth, size alone is decidedly an unreliable indication of a fish's age. Survey biologist Dr. Donald F. Hansen has

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found, however, that the study of a fish's scales gives a fairly accurate means for determining age. When a fish grows, its individual scales grow also. This scale growth takes the form of concentric ridges added around the unattached edges of the scale. In a year's growth, 5 to 50 ridges may be added to each scale depending on how good growing conditions were during that year. The ridges beginning a new year's growth are usually defined by a change in the angle at which the ridges are deposited on the scale.

Scale reading, which usually yields ages of fish accurate within one or two years, has become an important technique for recognizing stunted fish populations, for the scientist can judge by the age of the fish whether or not it has made adequate growth — that is, whether the small fish is still just a young fish or whether it is an older fish stunted in its growth because of a near-starvation diet.

Recognition of stunted populations is particularly helpful in promoting better fishing in lakes and ponds, for stunting seldom corrects itself. The addition of large predatory species, when these are absent, may be necessary to achieve a drastic thinning of the smaller fish, so that fewer fish are competing for the available food supply. Sometimes it is easier to remove all the fish from the pond or lake by draining or using fish toxins, and to start all over with a good combination of fish species.

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The Illinois

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OCTOBER 1963, NO. 12

Scorpion in Illinois

Although in tales of the far Southwest and Mexico the scorpion has long been associated with deadliness, Dr. Philip W. Smith, Survey taxonomist, reassures us that there is little to be feared from the only species which occurs in Illinois.

The single kind of scorpion known in the State is about one inch long and can be recognized immediately by the crayfish-like pincers and slender, segmented tail which bears a briar-like stinger at the tip. Scorpions have been found only in Monroe and Randolph counties, and even in this area seem to be restricted to the dry, rocky talus slopes at the bottom of the Mississippi River bluffs. Known as *Centuroides vittatus,* this species probably occupies a greater area of the United States than any other scorpion. It has been found in South Carolina, Georgia, New Mexico, California, Kentucky, Tennessee, Kansas, and Missouri, as well as all the Gulf States.

The sting of this species is considered no more serious than the sting of the honey bee. Although painful for a short time, the sting has no permanent aftereffects. Human encounter of scorpions in southwestern Illinois is rare, as they remain hidden under rocks during the day and move about in search of prey only at night. The small creatures feed on insects and spiders caught with their pincers. In Illinois they are more of a curiosity than a danger.

Biological Insect Control

In the 1880's and 1890's, when many of the known insecticides were largely ineffectual, many efforts were made to find insect predators and parasites which would control other insects of economic importance. This search was carried on with especial vigor when the cottony cushion scale threatened to annihilate the citrus industry in California. One among many, an Australian predacious beetle was discovered and imported into California; this Vedalia beetle proved extremely effective in controlling this scale and literally saved the citrus industry. This outstanding success excited entomologists over the whole continent with the possibility of using insect enemies of insects to destroy pest species.

Illinois has been the scene of many attempts to use this biological control. Very early in the century, fungus diseases were disseminated in attempts to control the chinch bugs. It was soon found, however, that during the dry years that brought on chinch bug outbreaks the fungus could not be maintained in the field effectively.

From 1929 to 1931, Natural History

Illinois' only scorpion. The top of the main part of the body is very dark; the remainder is lighter brown. (Photo by Wilmer Zehr)

Survey entomologists made a vigorous effort to develop parasites that would control the codling moth. A minute little wasp called *Trichograma minutum* was known to parasitize codling moth eggs. For three years, two or three men worked full time mass-producing these parasites, and releasing them in apple orchards, a difficult job requiring special cages and temperature- and humidity-control equipment. Two hundred thousand of these little wasps were liberated in 1929; 438,400 in 1930, and 568,400 in 1931. At best the parasite spread only a few yards from the point of liberation and in the treated orchards as a whole produced no significant reduction in codling moths. This experiment was considered unsuccessful.

At the same time federal entomologists in the eastern states were importing parasites of the oriental fruit moth, also abundant throughout southern Illinois' peach-growing area. Survey entomologists liberated several species of these parasitic wasps in Southern Illinois. One of them, a small brown parasitic wasp called *Macrocentrus ancylivorus* became well established and now year after year reduces the population of the oriental fruit moth from 20 to 50 per cent.

When the European corn borer made its appearance in the Midwest, attempts were made by the Survey cooperatively with the United States Department of Agriculture to introduce its parasites. Early attempts failed. Later attempts in 1944 and 1950 included chiefly four parasitic wasps and a parasitic fly. Eventually the fly became established in all parts of the State. During the past ten years this fly has parasitized 15 to 40 per cent of the overwintering corn borers; occasionally and locally in northern Illinois, parasitism reaches 80 to 85 per cent. Over the State as a whole 3 to 5 per cent of corn borers are parasitized.

Later, in cooperation with federal and state forestry personnel, a virus disease was introduced in an effort to control the European pine sawfly which had become abundant in the northwestern part of the State. This virus has proven extremely successful as far as control is concerned but difficulties are being encountered in obtaining virus suspensions suitable for spraying at reasonable cost. Unlike the parasitic wasps, the virus infections do not persist and have to be re-applied as sprays each time a new sawfly outbreak is spotted.

After the complete failure of the *Trichograma minutum* campaign in 1931, the Natural History Survey had no specialist on its staff charged specifically with trying to develop biological control methods. About 1950 Dr. Paul Surani began such studies, and in 1955 Dr. John Briggs was appointed to the Survey staff as insect pathologist, later succeeded by Dr. John P. Kramer. These biologists have made diligent search for parasites of insects, especially parasitic protozoa and microbes. Several disease organisms of economic species have been discovered but most of these flourish in the field only under unusual climatic conditions or under high densities of their host populations. The most promising seems to be the well-known bacterium *Bacillus thuringiensis* which can be applied as a spray suspension. This has proven effective on certain larvae but is short-lived so that additional applications must be made every few weeks to obtain good control. It is also expensive and genetically unstable.

These efforts demonstrate that developing biological controls for even our major insect pests is going to be expensive and at best its over-all results will be slow and unpredictable.

Thanks for the Helping Hand

How can a handful of investigators get enough facts and figures on pheasants to know the pulse of the ups and downs of pheasant populations over most of Illinois? Without information of this kind it is difficult to know whether research findings are successful when applied to large areas of the State or to know where trouble spots may exist. The Survey's wildlife biologists Ronald F. Labisky and William L. Anderson, working in cooperation with the State Department of Conservation, believe they have a remarkably accurate solution to the problem.

Several years ago they enlisted the co-

One of the first successful attempts to introduce parasites of the European corn borer in Illinois. The late Dr. T. H. Frison, former Chief of the Survey, and the late Dr. John M. Wright, former Survey entomologist, releasing parasitic flies and wasps in a corn field about one-half mile west of Champaign, Illinois, on June 28, 1944. (Photo by James S. Ayars)

operation of rural letter carriers and postmasters in the northern three-fourths of Illinois. Postcard questionnaires were distributed by postmasters to rural letter carriers in the 75 northernmost counties of the State. The carriers were asked to report the number of cock and hen pheasants observed along their mail routes for five consecutive days, from April 22 to 26. In 1963, 1,323 of these questionnaires were distributed and 1,203, or 91 per cent, were filled out and returned to the biologists.

Biologist Labisky reports that the Illinois pheasant population increased about 25 per cent in the past five years. Of especial interest was the increase in pheasant abundance in the contiguous block of counties — Piatt, DeWitt, Douglas, Moultrie, and Macon — which lies south-southwest of the center of the prime pheasant range in Livingston and Ford counties. In this same period there have been some notable pheasant declines, especially in the extreme northern tier of counties.

To the postmasters and rural letter carriers who have been of such great aid in obtaining this population picture, our sincere thanks.

Illinois Fishing Industry

At the turn of this century the Illinois River was considered the most productive river of its size anywhere in the world. Illinois fish were abundant and welcome in the markets of the East. At that time the livelihood of from 1,500 to 2,000 families came from fishing in the Illinois and Mississippi rivers and their larger tributaries. Since then this industry has declined, and in 1962 only 434 persons received all or part of their livelihood by catching and selling fish from these rivers.

Many factors led to the decline. Bottomland lake drainage has been especially destructive for fish. Most of these were drained for agricultural purposes between 1900 and 1923. Pollution from the cities in the northeastern part of the State had marked adverse effects on the rivers, espe-

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cially on the Illinois River as far downstream as Peoria. Modern technology in refrigerating and preparing sea fish contributed to the decrease in demand for Illinois products with a consequent drop in the price. In spite of this, there is still an active commercial fishing industry on Illinois' large rivers. Although only about 500 fishermen are active, they have an investment in nets, boats, motors, trucks, and refrigeration equipment inventoried in 1961 at $902,308.45.

The Survey's aquatic biologist, William C. Starrett, and fisheries experts William J. Harth and Alvin C. Lopinot of the Department of Conservation have been working together in recent years to obtain accurate statistics concerning Illinois' fishing industry and to try to devise ways of increasing it. Principal commercial fishes in Illinois rivers are carp, buffalo, drum, catfish, and bullheads. The catfish is the premium fish, usually bringing about 25¢ per pound in the rough at the local markets. Carp dominate the Illinois catch but the fisherman gets only about 4¢ a pound for them in the rough.

Figures gathered by Starrett, Harth, and Lopinot show that in 1908 the Illinois River alone produced over 20 million pounds of carp. In 1950 the entire catch from the Illinois River was down to 5,617,927 pounds, of which 3,943,974 were carp. In 1962 the Illinois River catch was down again, this time to 1,971,415 pounds, of which 1,009,367 were carp. This last sharp decrease in the Illinois River occurred because there were no longer many carp in the river big enough for marketing. The cause of this stunting is not known for sure, but it appears to be due to the great reduction in fingernail clams and other small organisms upon which the carp feed.

During this recent period the commercial fish catch from the Mississippi River has increased. In 1950 the Mississippi River catch amounted to 2,788,073 pounds. In 1962 it was 2,496,264, only slightly below the 1950 catch. Thus the catch from the Mississippi River, traditionally much lower than that from the Illinois, has now surpassed that from the former queen river of the State.

In spite of all these reverses, the total Illinois catch of commercial fish in 1962 was 5,820,527 pounds valued at $537,091.81.

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The Illinois

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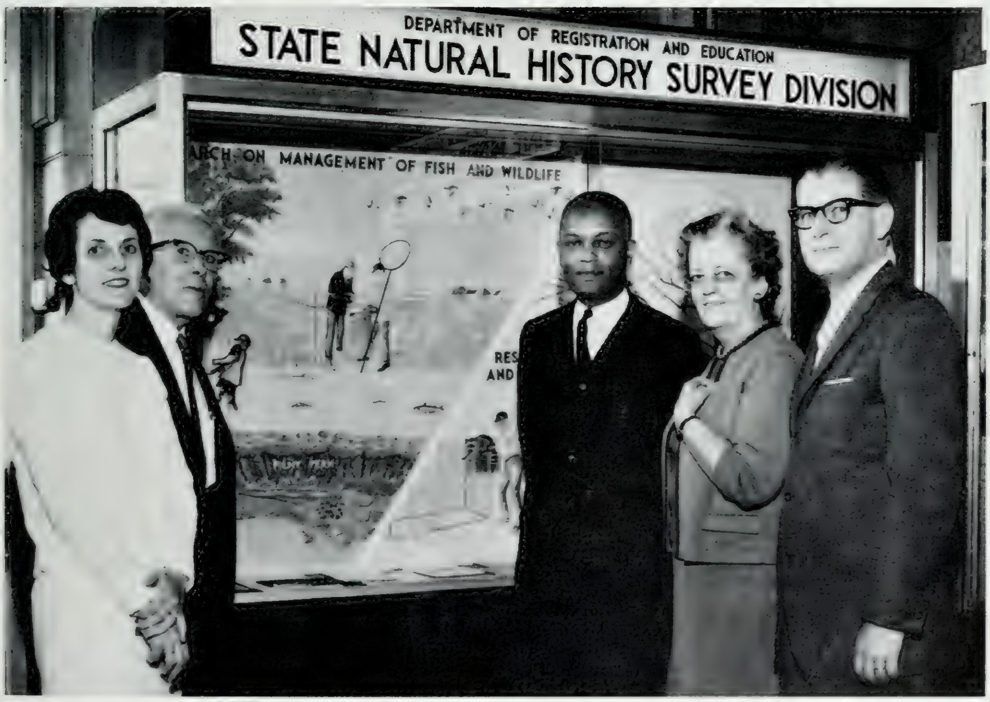
NOVEMBER 1963, NO. [illegible]

When in Springfield

How does the research of the State's scientific surveys touch the lives of the citizens of Illinois? To help the citizen to understand this relationship, the Geological Survey, the Natural History Survey, and the Water Survey (the State's three scientific surveys operating under the Board of Natural Resources and Conservation in the State Department of Registration and Education) have each installed a colorful exhibit in the corridor of the State Capitol building outside the entrance to the Department of Registration and Education. Accompanying these three exhibits is one for the State Museum, a division of the same Department.

Planned by the Survey's technical editor James S. Ayars and artist Mrs. Alice Ann Prickett, the Natural History Survey exhibit depicts the major groups of problems concerning Illinois resources on which the Survey staff bring to bear up-to-date



Visual aids in science. *From left to right,* Mrs. Prickett, Mr. Ayars, Director White, Administrative Assistant Mignon Huge, and Assistant Director Watson examining the Natural History Survey exhibit at the entrance to the Department of Registration and Education, near the east entrance of the Capitol building. (Photo by Survey photographer Wilmer Zehr.)

scientific information and techniques. Emphasized in the exhibit are research on the better management of wildlife and fishing, the identification and control of insect pests, studies on diseases of plants and wild animals, and a hint of the programs needed to carry on this work. The exhibit also contains a selection of Survey publications that present scientific findings of the scientific staff, or explain how the individual taxpayer can use these for his or her enjoyment or benefit.

When you are next in Springfield, we cordially invite you to step inside the east door of the Capitol building, turn to the left, and spend a little time at our exhibit.

Return Lend-Lease

In these *Reports* we have many times acknowledged gratefully the cooperation of the scientific groups in the federal government who have worked with our Survey staff in attempting to solve Illinois' problems. Cooperation, however, is not a one-way street. Our Survey has been glad to help the federal government by making available special scientific skills of our own staff in attacking problems of national concern.

Our Survey Chief Harlow B. Mills recently returned from such a "loan." Last year the National Science Foundation wanted to establish a contact office in science in Latin America between U.S. scientists interested in hemisphere problems and Latins who are interested in the National Science Foundation. Needed was someone with a wide knowledge of the biological sciences. The National Science Foundation requested Dr. Mills to be the chief scientist in their newly organized regional science headquarters for South America quartered at Rio de Janeiro. For this purpose Dr. Mills was granted a leave of absence by the Board of Natural Resources and Conservation, and assumed his duties with N.S.F. on August 1, 1962, going to Rio a few weeks later. Dr. Mills visited Costa Rica, Panama, Colombia, Peru, Chile, Paraguay, Uruguay, and various parts of Brazil, evaluating scientific facilities and discussing scientific problems with the personnel in various universities and research institutions in these countries. Dr. Mills returned to duty as Chief of the Survey on September 16 of this year. Reports of Dr. Mills and his team of scientists will be used in evaluating the need for research assistance in South American countries and will aid U.S. scientists whose problems extend into that area.

"A" for Acarology

September 2, 1963, marked the maturation date for the relatively new science of acarology, which is the study of mites and ticks. At that time 150 scientists from Japan, Indonesia, Australia, Africa, most countries of Europe (including three "Iron Curtain" countries), Philippines, Canada, and the U.S.A. met for six days to hold the First International Conference on Acarology at Fort Collins, Colorado. Dr. Lewis J. Stannard represented the Survey at these sessions.

Although mites and ticks have long been known to be of great importance as vectors of disease and as destroyers of crops and stored food products, mites especially defied adequate study for many years. Most mites are very small, less than one-twenty-fifth of an inch long, and some are even less than one-fiftieth of an inch long. What scientific study was done produced highly conflicting results. What was thought to be the same species would be found readily controlled by certain compounds by one investigator and immune to them by another. In other instances it appeared as if the same species would feed on certain crops in one part of the country but only on other crops in other areas.

After World War II a new kind of microscope, the phase-contrast microscope, became available to biologists. The peculiar power of juggling light rays made possible by this microscope soon demonstrated an abundance of minute, hitherto unseen characters on these tiny mites. Aided by this knowledge, it was soon found that what we had previously thought to be a certain kind of mite might be two or three or a dozen different kinds. Very often each kind had highly distinc-

Three of the probably 3,000 different kinds of mites in Illinois. Each of these three is smaller than the head of a pin. *Left,* the human chigger called *Trombicula alfreddugesi; center,* a feather mite called *Falculifer rostratus* which lives on the mourning dove; *right,* the clover mite called *Bryobia praetiosa* which often invades homes.

tive habits. It was discovered, for instance, that we have over forty instead of one chigger mite in Illinois, that certain ones feed only on certain wild animals, from snakes to rabbits, and only one habitually attacks man.

In this recent burst of discovery, the number of mites known in the world has jumped to 17,500 different kinds. This is twice the number of kinds of birds and five times the number of kinds of mammals living on the earth. The known list of diseases caused by organisms carried by ticks and mites has grown steadily. This includes such diseases as tularemia and Rocky Mountain spotted fever whose disease organisms are transmitted by ticks in Illinois, plus many others not so well known which affect non-humans primarily. We have found that certain mites, especially those affecting orchards and ornamental plants, have become serious pests following the widespread use of DDT and other new insecticides. To combat these mite pests, new and specific compounds called miticides or acaricides were tested under the critical eye of entomologist Dr. L. L. English. We are finding that certain mites feed on other destructive mites and are our friends.

Because mites are so tiny, the big problem with any mite program is the extreme difficulty of distinguishing between pest species, harmless species, and helpful predaceous species. To tell them apart requires high magnifications of the microscope, special lighting systems, and special ways of preparing the mites for study. To add to our difficulties, mites are easily transported and new pest species from other parts of the continent or the world are continually becoming established in Illinois. The Survey's mite specialist, Dr. Stannard, has for several years been building up the Survey's scientific reference collection of these little animals and maintains contact with mite specialists in other parts of the country who can give us aid in solving some of our tricky problems of identification.

Water, Water Everywhere

In winter, when snow covers the ground, did you know that your evergreen trees and shrubs might be dying of thirst? If the surface of the ground is frozen, the water from the melting snow will simply run off and not penetrate into the ground. The sunlight even in winter activates the green material of the evergreen plant leaves and this activity uses up water from the plant tissues. If the soil around the

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roots below the frozen line does not have available moisture, the tree is forced to spend too much of its moisture keeping up with the photosynthetic activity forced on it by sunlight, and the tree will simply dry out too much and be severely injured or may die.

Dr. J. C. Carter, head of the Survey's Section of Botany and Plant Pathology, points out that affected trees are usually slow to recover, and winter injury, which appears in late winter or early spring, develops as extensive browning and possible death of foliage on one-year-old or older shoots. If the situation becomes critical, the plants may die by spring. Home owners and arborists may readily confuse winter injury with symptoms of various tree and shrub diseases.

In order to guard against injury from winter drought, the soil around the roots of trees and shrubs should be soaked to a depth of at least eighteen inches before the ground freezes. Water should be allowed to run slowly into the soil and to soak into it over a period of several days. Survey plant pathologist Dr. Donald F. Schoeneweiss recommends the use of a watering needle or pipe to insure depth penetration of moisture to tree roots. A three-foot length of ½-inch pipe that can be attached to the garden hose will serve as a watering needle. The open end of the pipe should be tapered to allow for easy insertion into the soil. Mulching with corncobs, straw, or other suitable material will help prevent deep freezing and also assist in maintaining a sufficient amount of water in the soil around the tree roots. Here again the mulching material should be applied just before the soil freezes in order to prevent rodents from nesting in the mulch and feeding on the bark of the mulched plants.

Dr. Schoeneweiss reports that the plants most susceptible to winter drought injury are the broad-leafed evergreens such as boxwood, holly, and euonymus. Next are the narrow-leafed conifers and of these the most susceptible are yews, arbor-vitae, and junipers. Pine, spruce, and fir are slightly more drought resistant.

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DECEMBER 1963, NO. 14

Paging Miss Muffet

The brown recluse spider, a southwestern species with the scientific name of *Loxosceles reclusa,* and first reported in southern Illinois in 1959, has recently been found as far north as Moultrie County. It can inflict a painful bite which eventually leads to the skin sloughing off in the bitten area, leaving a scar. Unlike Illinois' other poisonous spiders, the two black widows (of which only the female is poisonous), both sexes of the brown recluse spider can give poisonous bites. The brown recluse is medium-sized with a light brownish body about ⅜ inch long and dark brown legs. Its most distinguishing feature is a broad, dark, fiddle-shaped mark extending down the back of the combined head and thorax. Our spider expert John Unzicker warns that the spider's habit of living in and around dwellings makes human contact possible.

The brown recluse spider showing the fiddle-shaped mark extending down the back of the cephalothorax (the combined head and thorax). (Photo by Survey photographer Wilmer Zehr.)

Care should be exercised in handling clothing which has hung unused for a long time, and in cleaning storage areas.

We would like to know if the spider occurs in other Illinois localities. If you see spiders you suspect might be the brown recluse, please send them to Dr. M. W. Sanderson, the Survey insect identification coordinator.

Fickle Nature

For decades fisheries investigators have tried to figure out ways of improving fishing in streams and ponds. The ideal sought has been a combination of fish species which would maintain the largest population of legal-sized fish and thus result in the maximum amount of fishing pleasure. The kernel of the problem is knowing what kind of fish growth can be expected under various water conditions. In spite of much investigation, however, comparatively little reliable information has been accumulated concerning the actual number of pounds of fish which can be produced in an acre of water.

To find out what fish harvests could be expected in Illinois, especially in farm ponds and small lakes, the Survey embarked on a cooperative investigation with the State Department of Conservation and the McGraw Hydrobiological Laboratory at Dundee. The Survey's aquatic biologist, Dr. George W. Bennett, planned a series of tests using fifteen ponds of about an acre each, stocking each pond with only one species of fish. Largemouth bass, smallmouth bass, bluegills, bullheads, and perch were chosen as a representative set of angler's species. In 1956 Dr. D. H.

Buck joined the Survey staff to take charge of the operation, which has continued throughout as a cooperative program with the Department of Conservation. He and Mr. Morris Whittaker got the project into operation; sometime later Mr. Charles F. Thoits replaced Mr. Whittaker on the project.

In the Dundee experiments, three similar ponds were stocked with similar numbers and sizes of a single species of fish. One of the three ponds was selected as a control and remained uncropped and unstocked after the initial stocking. One of the other two ponds was cropped at a predetermined rate, and part of the fish so taken were added to the third pond, which thus received stock at a predetermined rate. At the end of the first growing season after stocking, the control pond was drained, the fish censused and held alive, the pond refilled and the fish returned. At the end of the third year all ponds were drained and censused and the fish moved to a new set of three ponds. At Dundee five sets of three ponds each were being used in this experiment.

Censuses of the three similar ponds containing a single species of fish usually showed a wide variation in the poundages of these fish from pond to pond and year to year. These findings are at variance with similar limited experiments done in other states. In the latter experiments, the poundages of fish tended to approximate a specific figure, regardless of the number or weight of fish stocked originally. Such uniformity has not been found in the Dundee ponds, and it is desirable to determine whether ponds in other areas of the state will show a similar large variability of production or will tend toward uniformity.

The ponds in the Dundee region are somewhat atypical of Illinois ponds in general because the summer water temperatures are lower than for surface ponds in the rest of the state and the soil is of very recent glacial origin. In order to test the probable effect of these differences on the fish populations, experiments comparable to those performed at Dundee will be repeated at a new location in Marion County, near the center of farm pond building in the state.

Attention, Plant Lovers

The home gardener, the house plant grower, and the commercial florist will be delighted to hear that Survey plant pathologist Dr. Junius L. Forsberg's new book *Diseases of Ornamental Plants* is now available. Dr. Forsberg combines nearly thirty years of knowledge and experience in this handy manual, which is an enlarged edition of the original 1946 publication.

The most commonly encountered diseases of 60 categories of flowering plants are diagnosed and treatment is recommended for each. The categories, ranging from *African violet* to *Zinnia,* are chiefly the common flowers grown in this area, plus a few shrubs such as azalea, rhododendron, and rose, but no trees. Some plants such as Freezia have only one disease listed, others such as ferns, only two; the more susceptible plants have more enemies, including gladioli with thirteen common diseases and roses with nineteen. Profusely illustrated with 200 photographs of diseased plants plus line drawings of many plant parts and disease structures, this book is written especially for use by the people who grow the plants. In addition to the disease symptoms, informative chapters explain the elementals of disease organisms, general practices in the control of plant diseases, directions for handling and formulating fungicides, and directions for soil sterilization. If laboratory diagnosis is necessary for verifying the identification of the disease, the grower is so warned.

The University of Illinois cooperated with the Survey on this project by printing this manual as Special Publication No. 3 of the College of Agriculture, where it may be purchased for $2.08 (including sales tax).

Half-a-Century Census

Man has wrought great changes in the natural landscape of Illinois. What effect has this had on the wild birds? At the turn of the century this question bothered Stephen A. Forbes, first chief of the Sur-

Dr. Alfred O. Gross, left, and helpers on a collecting trip near St. Joseph, Illinois, May, 1908. This trip was not part of the bird censuses of 1906, 1907, and 1909 but was part of the early over-all studies of Illinois animals which included the bird censuses. (Photo through the courtesy of Dr. Gross, Professor *Emeritus* of Biology, Bowdoin College.)

vey. Even at that time the great change in Illinois landscapes had already been brought about by the ax and plow. Perhaps because of his army training, Forbes was a great one to marshal forces in battle, and at that time, when adequate control measures were known for only a few of the many destructive insects, it was thought that birds might be a potent ally in insect control. Forbes wanted to know the total number of birds occurring in the whole State, and in what habitats they occurred. Together with Alfred O. Gross, Forbes devised a strip census method whereby two men 30 yards apart walked a straight line transect across the country and counted all the birds that flushed in the 30-yard strip.

Prior to white settlement, the population of native Indians probably did not exceed 10,000 in Illinois. The areas of natural vegetation which they cultivated were only a minute fraction of the area of the State. At that time, the State's 35.8 million acres were divided roughly into 14 million acres of forest and 21 million acres of prairie, including about 1.5 million acres of marshland. This proportion prevailed until about 1800. Soon after, farming in Illinois began in earnest. By 1900, only 4 million acres of forest remained and a million acres of prairie and marsh combined; the rest was in various stages of cultivation or urbanization. The Forbes and Gross census, conducted in 1906–1909, was made at almost the exact time that these great changes had come about.

How have the native birds adjusted to this new situation? Fifty years after the Forbes and Gross census, Survey biologist Dr. Richard R. Graber and his wife, Dr. Jean W. Graber (also an expert ornithologist), set out to duplicate the Forbes and Gross census, using the same methods, visiting many identical spots, and following roughly the same transect lines. As Gross and his helpers had done, the Grabers made two winter and two summer transects of the State, each of about 200 miles, for a total of 833 miles. Then they tabulated their records and compared their findings with the historic census made 50 years before.

In this last 50 years Illinois forests were up about half a million acres but the prairie and marsh had been greatly reduced. The total number of birds in the State, however, had remained practically the same. From the Forbes-Gross data it

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was estimated that the adult summer bird population in 1909 was 61,333,000; the Grabers found it to be 59,778,000 in 1957 and 65,586,000 in 1958. But the proportion of the different species making up this total have changed remarkably. The Grabers noted that a few bird species have adapted well to the agricultural situation. Thus redwinged blackbirds were up from about 5 million in 1907 to 11 million in 1958, and horned larks were up from 1.5 million in 1909 to 5 million in 1958. The number of redwings has increased because they have adopted agricultural lands as nesting sites, a relatively new change in their behavior. The rise in horned larks, on the other hand, occurred simply because horned larks thrive on almost bare ground such as the spring condition of cultivated fields. A marked drop in urban populations of flickers appears to be due to the starlings, not regularly present in Illinois until the 1920's, now numbering 3 million breeding birds. Wild hay and pastures are gradually being supplanted by cultivated hay. This favors a few species such as dickcissels, bobolinks, and redwinged blackbirds, but cuts down sharply on the numbers of some other birds. Prairie marshlands are practically disappearing from Illinois; this is mirrored in the sharp decrease found in rails, summer resident water fowl, bitterns, and certain marsh-inhabiting song birds.

A detailed account of this latest census and the fifty-year comparison with the earlier one is contained in the Grabers' new publication "A Comparative Study of Bird Populations in Illinois, 1906–1909 and 1956–1958," published this month in the Illinois Natural History Survey Bulletin. This is a technical research report of interest especially to ecologists, serious ornithologists, and those interested in the changing wild life of Illinois. (Available from the Survey at one dollar per copy.)

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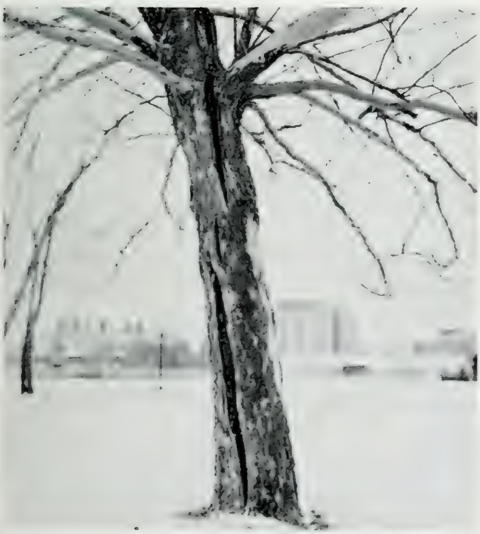
JANUARY 1964, NO. 15

Jack Frost in Action

Most puzzling and annoying is the formation of frost cracks in trees. Frost cracks are long up-and-down openings in the bark and wood that extend into the center of the tree. Trees most subject to cracking are oak and London plane; less susceptible are elm, various maple species, horse chestnut, linden, and willow. At least on London plane, once these frost cracks occur, they continue to open each winter and close in the spring. Callous tissue forms along the edges. After repeated splitting, considerable callous forms along the edge of the crack. Wood-decay fungi enter the cracks and over a period of years cause rotting of the heartwood.



Frost cracks on London plane tree. Next April these cracks will close up and during the summer they will callous over. Next winter they will re-open.

It was previously thought that the splitting was caused by sudden drops of temperature considerably below freezing. Survey pathologists Dan Neely and E. B. Himelick, using timing devices placed on closed cracks of London plane trees, found that this is not the case. Old cracks open when the air temperature gets as low as +8° F. It doesn't matter whether the temperature goes down suddenly or gradually. In efforts to find a remedy for this damaging condition, Dr. Neely and Dr. Himelick thought that it might be caused by lack of moisture in the soil before winter. They irrigated London plane through the fall but found that the application of additional water had no observable effect on crack formation. They are now testing various mechanical means in an effort to prevent frost cracks from reopening. They hope to initiate studies on the physiology of the trees in an effort to find out why the cracking occurs. If they knew why it occurs, the chances are that they would be able to figure out ways of preventing it.

Honker to Starboard

The Survey's studies on migratory waterfowl are aimed primarily at learning more about the migratory habits and patterns of ducks and geese in order to work out better details of their management as a wildlife resource. These studies, however, have another aspect which is beginning to attract serious attention. Some of the larger birds present a potential hazard to aircraft. Except for starlings, probably the most potentially dangerous species include gulls, herons, hawks, vultures, geese,

and ducks. Gulls, herons, hawks, and vultures are only of slight local importance; geese and ducks present a greater potential hazard to aircraft.

Survey wildlife specialist Frank C. Bellrose, who has for years censused ducks and geese migrating through Illinois, has clocked many hundreds of hours in the air checking on the birds. Says Frank:

"Observations from a light aircraft indicate that birds flying toward an aircraft are less likely to strike it than when both are moving in the same direction. On sighting an aircraft at close quarters most birds will fold their wings and plummet earthward. Strong-winged birds, if above the center of the aircraft, will usually climb. We evade birds by reducing power and pulling the nose up, probably not recommended for airliners because of the danger of stalling."

In mid-America geese are the greatest hazard to aircraft because they occur in large flocks, are large in size, have relatively slow flight, and fly at high altitudes. Most geese migrate at altitudes between 3,000 and 8,000 feet, occasionally reaching 10,000 feet, rarely getting as high as 15,000 feet. Each fall between 700,000 and 900,000 Canada, blue, and snow geese leave Hudson and James bays for their wintering grounds in the Mississippi Flyway. Many of them pass close to municipal airports, including those at Toledo, Ohio, and especially Lambert Field, St. Louis. Usually about 100,000 Canada geese move into the marshes 50 miles northwest of Milwaukee, Wisconsin, both during the fall and spring migrations. In migrating between this area and southern Illinois the bulk of the geese pass 25 miles west of Milwaukee's Municipal Field and 50 miles west of Chicago's O'Hare Field. At times stray flocks pass over or very close to both airports. The principal period of concentrated migration is October, with a reduced number of birds in the air until mid-December. The northward movement of geese from their wintering grounds starts in early March and extends through most of April.

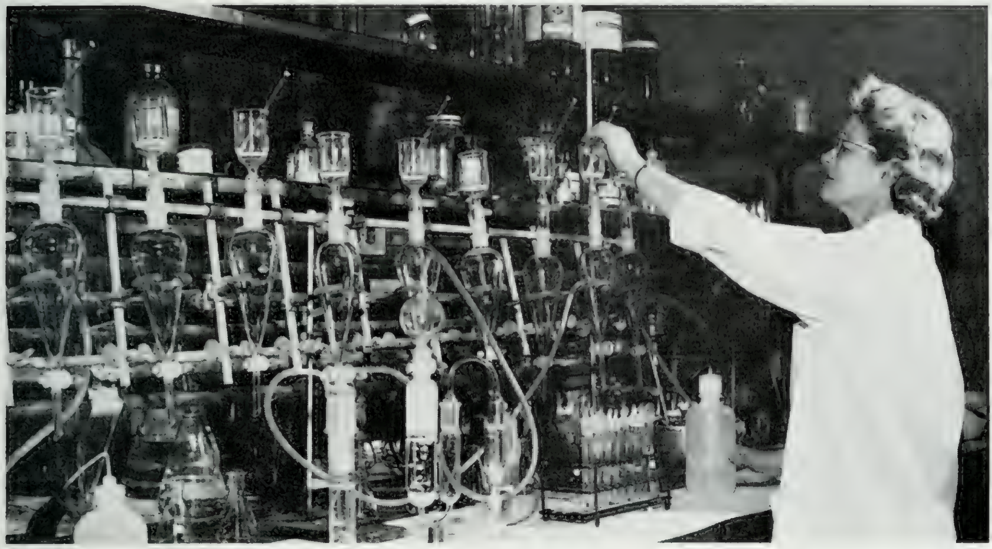
The Mississippi Flyway has the largest duck population of any comparable area in the country. Each migrating season from 7 million to 15 million ducks pass along its routes between breeding grounds on the northern Great Plains and wintering grounds in Arkansas, Mississippi, and Louisiana. The migrating pattern of these ducks is concentrated by the Mississippi and Illinois rivers which funnel them immediately to the south. Because of this channeling effect, more ducks pass in the vicinity of Lambert Field, St. Louis, than any other major air terminal east of the Rocky Mountains.

The Survey, through a research grant from the National Science Foundation, has obtained the cooperation of the U.S. Weather Bureau on a project to plot the direction, time, and intensity of migrating bird flocks throughout the Mississippi Flyway. Twenty radar stations of the U.S. Weather Bureau, distributed from Buffalo to Miami and from Minneapolis to Brownsville, are taking 5-minute samples of the sky every hour for the passage of birds. These are being coordinated at the Survey's Havana, Illinois, laboratory by Bellrose and his helpers. When this great fund of information is interpreted, we will know a lot more about the relationship of bird migrations to potential aircraft strikes.

Insecticide Detector

In 1945 DDT, the first of the "magic insecticides" to emerge from World War II research, was used extensively on Illinois farms. In 1947 the late Dr. Carl Weinman, then entomologist for the Survey, detected DDT in milk from Illinois farms. This was among the first evidence that DDT and allied chemicals could be transmitted from fodder, through an animal, into human food.

Since that time additional organic compounds have proven to be extremely effective as insecticides, including especially heptachlor, aldrin, and dieldrin. These are called the chlorinated hydrocarbons. In the ensuing concern about these insecticides as hazards to both human health and wildlife, one of the biggest obstacles to understanding the problem has been the difficulty of determining the amount of these chemicals in a given sample of tissue, fodder, or soil.



Glassware all shining, Mrs. Wilson is about to start a new run of insecticide extractions from butterfat. This will be just one of the many steps necessary to find out exactly which insecticides and how much of each were present in the milk given by certain cows on a certain day. (Photo by Survey photographer Wilmer Zehr.)

At the time of Dr. Weinman's historic discovery of DDT in milk, we relied on insecticide identification by bioanalysis. Suspected insecticides were concentrated in a fat solvent and applied to highly susceptible flies. If the flies died, this was considered evidence of the presence of the insecticide. Very crude by today's standards, but it worked. In the 1950's techniques were discovered for converting the insecticides to colored compounds. In 1960 a technique known as paper chromatography was applied to this problem with great success, and in 1962 an ultramicroanalysis called gas chromatography was used for even greater precision.

These bare words tell nothing of the intricate techniques which go into detecting and measuring insecticides in a given sample, the difficult job daily facing Survey entomologists W. N. Bruce and Jean Wilson. Testing milk is a good example. First about 10 grams of butterfat is taken from the sample and weighed accurately (there are 454 grams in a pound). This is treated with potassium hydroxide to convert the fat into soap. This releases the insecticide from the fat and the insecticide itself is then extracted with ultrapure petroleum ether, technically known as hexane. This solution is then treated with several special compounds to extract from it all coloring matter and interfering compounds which would be due to compounds other than the insecticides. This is called the "clean-up" operation, and it takes about two days to run any one sample. After the clean-up, we add other chemicals that combine with the insecticides to form specific colors. In techniques currently being employed by Dr. Bruce and Mrs. Wilson, DDT forms blue, DDE (a related compound to DDT) forms pink, heptachlor forms cerise, heptachlor epoxide forms yellow, aldrin and dieldrin form red-orange.

Heptachlor and its relative heptachlor epoxide present additional technical problems of separation as does the separation of aldrin from dieldrin. The separation of the two components of each of these pairs takes an extra day. The suspected mixture is run through a florisil chromatographic column. This column is simply a tube filled with a special aluminum-silicon floride compound called florisil, which is a white granular material that looks like coarse salt. The solution of the sample is trickled down this column of florisil. Treated with one solvent system, the florisil will hang onto the heptachlor epoxide and let the heptachlor go by; this

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separates the heptachlor from the heptachlor epoxide. If now the florisil is treated with another special solvent, it releases the heptachlor epoxide which can be washed out separately. The same technique applies to aldrin and dieldrin.

The colored compounds can be measured in a machine called a spectrophotometer, that records the amounts of each color in the sample. This method can be used only for samples with moderately large amounts of insecticides, because it can determine amounts only as low as five or ten millionths of a gram (a millionth of a gram is called a microgram). Paper chromatography is more sensitive, detecting amounts as small as one-tenth of a microgram. This method is based on the physical properties of the insecticide molecules. Although the theory is technical, in practice the method is relatively simple.

Much smaller amounts of insecticides can be detected by the ultramicroanalysis called gas chromatography with electron capture detection. This machine utilizes the beta radiation from tritium. This machine has a high-temperature unit in which the insecticide is converted into a gas, and the machine actually measures the insecticidal interference of a stream of electrons in the detector cell. This method can detect .00001 microgram of insecticide, which is one-hundredth of a billionth of a gram.

Not only does this analytical program require tremendously expensive equipment, but this equipment must be fantastically clean. Over half of the time is consumed in repurifying the reagents used and washing every beaker, test tube, and stirring rod, as well as the larger equipment, with purifying solvents that will remove any trace of contamination. This is a laborious job, but necessary for accuracy.

As one can readily realize, these new and tremendously refined tools are bringing an entirely different perspective into our insecticide detection and our knowledge of what happens to insecticides. It has enabled the Survey to embark on new experiments testing the accumulation of insecticides in soil, the amount of insecticide that plants extract from the soil and store in their tissues, the amount of this insecticide that gets into food and its accumulation in various species of wildlife. Even greater promise of significance is given by new experiments finding out what happens to insecticides stored in the tissues of animals when the insecticide is completely removed from the animal's diet. These are some of the new avenues of discovery opened up by these newer techniques in insecticide analysis.

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The Illinois

NATURAL HISTORY SURVEY REPORTS

FEBRUARY 1964, NO. 16

Visual Aids

Two of the Survey's most popular circulars, *Pleasure with Plants* and *How to Collect and Preserve Insects*, were so warmly received that several years ago we decided to make a technical movie to go with each, which could be distributed for high school use. Mr. James S. Ayars, the Survey's Technical Editor, and his assistant, Mrs. Blanche P. Young, report that the demand for the films has surpassed all expectations. The two are entitled *How to Collect and Preserve Plants*, made under the scientific direction of Survey botanist R. A. Evers, and *How to Collect Insects*, made under the scientific direction of Survey entomologist M. W. Sanderson. Dr. Evers and Dr. Sanderson enlisted high school students to enact the fascinating role of finding out something of the life around us. We now have several copies of each film, all of them signed up until next June 15. If you would like to borrow these for summer or fall classes, reservations should be made without delay. The films are supplied free for class use if the users pay all transportation charges. Inquiries should be sent to Mr. Ayars at the Survey.

Illinois' winter scorpion fly, *Boreus brumalis*, perched on a moss clump. (Photo by W. E. Clark, former Survey photographer.)

Insect Insomnia

For life in the out-of-doors, the onset of winter signals dormancy or hibernation, a time of sleep. The annual plants die, the deciduous trees shed their leaves; insects, spiders, ground squirrels, and many other animals seek sheltered places for hibernation or make internal adjustments to withstand the cold. The birds, their family chores over, forage simply to exist through the time of stress.

As if afflicted by some kind of insomnia, a few small Illinois insects do quite the opposite. At the onset of winter they begin their most active period. When snow covers the landscape and temperatures are hovering at near-freezing temperatures, the adults of these insects emerge, seek their food, mate, and lay their eggs.

Three entirely different kinds of Illinois insects belong to this winter group. Almost all of them are less than a quarter-inch long, have abbreviated wings, and are dark in color. The winter crane flies (belonging to the genus *Chionea*) and the winter scorpion flies (belonging to the genus *Boreus* of the order Mecoptera) spend the warmer part of the year as larvae in leaf mold or moss on the forest

floor. The small adults of these are rare and difficult to see except when snow is on the ground. Then these little dark insects can be spotted quite readily. This is why Survey entomologist L. J. Stannard literally follows the snow plows in search for them. To date he has found that they occur only as isolated colonies in southern Illinois.

More abundant are the winter stoneflies whose young live in rivers and unpolluted streams throughout most of Illinois. In addition to the small dark ones, some of the adult winter stoneflies are gray, reach a length of half an inch and have long wings. Adults of these winter stoneflies like to climb on concrete bridges and fence posts near the stream. You may have seen entomologist H. H. Ross stopping at bridges and picking off these scurrying, ant-like little creatures.

For Dr. Stannard and Dr. Ross these winter insects have a fascination other than their peculiar winter habits. The Illinois populations of certain species are several hundred miles from the main range of the species. This means that at some time in the past the intervening areas had a climate different from the present one that allowed these species to disperse between the two areas. There is good reason to believe that the isolated Illinois populations are the result of climatic changes associated with the glaciers that at times extended into the State.

With the cooperation of the National Science Foundation and biologists throughout the eastern half of the continent, these Survey entomologists are trying to piece together the species movements and regional extinctions that produced these peculiar distributional patterns of winter insects. There is a possibility that we may be able to figure out more exactly than has been done before what were the conditions for life south of the glaciers in Illinois when these great masses of ice extended as far south as Mattoon and Carbondale.

Bobwhite

A favorite of every outdoor enthusiast is the bobwhite with his clear piping call. In autumn the whir of bobwhite wings is music to the ears of thousands of Illinois hunters. The bobwhite or quail is the only native member of the quail-partridge-chicken order of birds still present in Illinois in sufficient numbers to be hunted. It is primarily a bird of the forest edge and is especially abundant in the mixed farm and woodland areas of the southern third of the State.

Tucked among these areas of original forest land are patches that were originally prairie, primarily in south central Illinois. In these prairie areas, which are now farmed, quail are less abundant than in the more forested areas of southern Illinois. The areas of prairie farmland having moderate amounts of brushy cover — usually located along roadsides, fences, or ditches — frequently provide good opportunities for quail hunting. As a consequence, the fall populations of quail in these areas are highly exploited by hunters.

To test the possibility of improving quail hunting in these areas through habitat management, in 1962 the Illinois Natural History Survey and the Illinois Department of Conservation initiated a study of bobwhites on a 16-square-mile area near Bogota in southwestern Jasper County. An initial census gave information on the size of the late winter quail population. Later, using traps baited with hen quail, 74 males and 7 females were captured and marked with plastic back-tags and aluminum leg bands. The back-tags measured 1 by 2½ inches and were attached to the quail by straps looped around the base of each wing; when in place the ends of the straps were stapled to the tag. These tags, developed by Survey wildlife researcher R. F. Labisky, do not hinder flight and, by the use of powerful binoculars, provide a means of identifying individual free birds in the field.

The Survey's quail specialist Jack A. Ellis reports several interesting findings from the first year's observations. Whereas bobwhites in forested areas tend to remain in a relatively small territory, on the prairie they appear to be more highly mobile. During the breeding season, male bobwhites were captured from one-quarter mile to over three miles from the point of original tagging. Why they move more

on the prairie than in the forest is not known. It has also been discovered that the prairie area provides suitable nesting habitats for quail and, during the breeding season, they appear to attract quail from the surrounding forested area.

82-Acre Test Tube

One of the most perplexing problems concerned with fishing is: what kinds of fish and how many should be put in new lakes covering fifty to several hundred acres such as those built to supply drinking water and recreation for small cities. We know that differences in lake bottom, the amount of minerals and organic matter coming into the lake with the run-off from the water shed, lake vegetation, temperature, and many other factors have an effect on fish productivity. To run a series of experiments on fish production, taking all of these variables into account, would require literally hundreds of experimental lakes in order to get sufficient replication of results. This type of replication is easy to achieve with laboratory cultures of flies or bacteria, which can be grown in small test tubes or dishes, stacked in wire containers, and piled high in incubators. With 100-acre lakes, this is not so simple. Each lake might cost $250,000, and finding enough suitable sites would be virtually impossible.

An alternative method used by Survey fisheries researchers is to stock the same lake with different combinations of fish at several year intervals. Each lake is drained at the end of four or five years, the fish counted and held in huge plastic tanks, then returned unharmed to the lake. This process continues until the experiment is completed. Fisheries biologist Donald F. Hansen has been conducting such a series of tests on Lake Glendale in Pope County. The lake was stocked first in 1940. It was opened to fishing from May to September of each year and the attendant recorded the number, kind, and weight of each fish kept and the amount of time the fisherman had spent catching them. This gives an excellent index of the quality of fishing.

The 1940 stocking was at the rate of one adult largemouth bass and three adult bluegills per surface acre of water. It produced completely satisfactory bluegill fishing from 1942 through 1946, but very poor bass fishing except on the first day of the 1942 season. After Lake Glendale had been drained and all fish counted at the end of the 1946 season, the lake was restocked at the rate of 27 bass and 41 bluegills per acre (mixed young and adults of both species). Compared with 1942–46, during 1948–50 bass fishing was much better while bluegill fishing was not as good.

A few hundred of the bass hatched in 1940 evidently "turned cannibal" and grew rapidly to large sizes, but most of this hatch (the non-cannibals) and all

Quail showing numbered tag in place. With good binoculars, these numbers can be recognized on birds in the field at a considerable distance. (Photo by Survey photographer Wilmer Zehr.)

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those hatched in other years grew very slowly. This slow pattern of growth is presumed to have been due to overly successful reproduction. So many young bass were hatched that there was not enough space or food for good growth. On the contrary, bluegills spawned in Lake Glendale grew normally and reached the harvestable size of six inches or larger within two years after the 1940 stocking and within three years after the 1946 stocking.

The stocking of 27 bass per acre in 1946 provided outstanding bass fishing in 1948 and fairly food fishing in 1949 and 1950. Some of the original bass stocked in 1942 and 1946 grew as much as two pounds during their first year in the lake. The original bluegills also grew rapidly but for some reason the original bluegills — including those stocked at a rate of 41 per acre — contributed little to the fish harvest.

Dr. Hansen found that the stunted bass tended to be short lived. Whereas bass often live as long as 10 or 15 years, most of the stunted ones were gone by the end of the fifth year, and few reached what at that time was the legal size of 10 inches. The cause of death might have been malnutrition (though the stunted bass seemed to grow a little each year); death from hook injury is another possibility.

A bass stocking that is still heavier than 27 fish per acre (for example, 50 per acre) would seem to be the next experiment in studying fish production in reservoirs like Lake Glendale. This would provide more adults to prey on the new hatches of young bass. Each adult predator would have less area to cover so that the total number of surviving young might turn out to be considerably smaller than the number that survived in the present tests. Another possibility, however, is that additional kinds of predators should be tried along with the bass; for example, dogfish (presently being tested in ponds near Glendale), gar, flathead catfish, and channel catfish.

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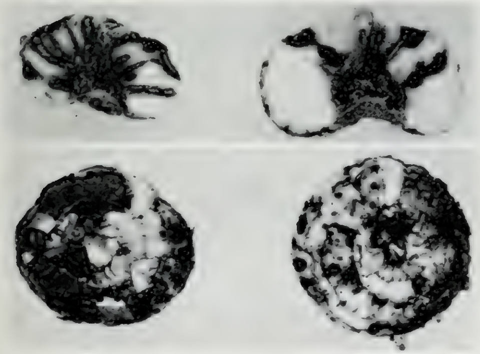
MARCH 1964, NO. 17

If It's Not One Thing . . .

Ten years ago the biggest headache to gladiolus growers in Illinois was a disease called bacterial scab. Another disease of glad corms, Stromatinia rot, was of only sporadic importance. Remedies then in use to control bacterial scab were only partially effective. At that time an unusual occurrence of white grubs in the gladiolus plots caused unusual damage to the corms. Survey plant pathologist Dr. J. L. Forsberg asked fellow entomologist J. H. Bigger for a suggested white grub control and, acting on the advice received, treated some of the area with the insecticide aldrin. This controlled the white grubs and, to his surprise, Dr. Forsberg realized that it had controlled the scab as well. This treatment for scab proved highly effective in commercial plantings, but as the scab problem receded the Stromatinia rot became more and more severe each year. In some years it turned out to be as big a headache as bacterial scab had ever been.



Stromatinia rot in gladiolus corms. The sliced away upper corms show how the rot extends into the heart of the corm.

Another problem of gladiolus corms was that of bulb mites which also lived in the soil. Bulb mites were also controlled by aldrin. Dr. Forsberg suddenly realized that severe Stromatinia rot was associated with a scarcity of mites and that severe scab attacks were associated with an abundance of mites, and decided to study the role of the mites in relation to these two diseases.

The story that emerges many experiments later is indeed a curious one. The mites, the bacteria producing bacterial scab, and the fungus that produces Stromatinia rot, all live together in the soil. A favorite food of the mites is the Stromatinia fungus, and if the mites are abundant they eat up so much of it that there is little left to harm the gladiolus corms. At the same time the mites, working through the soil, carry the bacterial scab organism from corm to corm and in this way infect a high proportion of all the gladiolus plants with scab. If there are no mites, there is no way for the bacterial scab organism to get from gladiolus to gladiolus and little bacterial scab develops. Under these conditions, however, the Stromatinia fungus grows like mad and is extremely destructive to the glads.

Armed with these new discoveries, Dr. Forsberg has now devised a simple schedule of soil treatments to protect glads against these two diseases: an insecticide to control the mites and thus prevent the spread of the bacterial scab organism, and a fungicide to control the fungus that produces Stromatinia rot.

Insect Chemosterilants

One of the most serious and persistent threats to the cabbage, turnip, and radish growing industry in Illinois is the cabbage maggot. The adult looks much like a house fly but it lays its eggs around the base of the young cabbage, turnip, or radish plants; these hatch into little white legless maggots that burrow into the roots of the plants. Young plants may be killed, necessitating replanting; older plants may be stunted and misshapen and the turnip or radish bulb made practically valueless in today's highly competitive truck crop markets. Only about 4,000 acres of cabbages, turnips, radishes and their relatives are grown in Illinois but these are on high value land mainly in the vicinity of Chicago, Rock Island, Peoria, and East St. Louis. Cabbages, of which 3,200 acres are grown, give an average crop value of $360 per acre; if the market is just right they may bring $1,000 per acre. In Illinois the annual market value of these crops totals over $1,500,000. With such high stakes, control of the cabbage maggot is a "must" for profitable operation.

Until recently, the insecticides dieldrin, aldrin, heptachlor, and chlordane gave almost perfect control of these maggots. About five years ago, however, growers in the Pacific Northwest discovered that strains of the cabbage maggot had become established that were resistant to these insecticides. This strain either spread across Canada or arose spontaneously in different areas. At any rate, it now occurs throughout Canada, through Wisconsin, and now has been detected in some areas in Illinois — at least in portions of the Chicago area. Survey entomologist William Luckmann has found that certain other insecticides called organophosphates give effective control of the maggot and these recommendations will be available to truck farmers this spring.

What if the maggot becomes resistant to organophosphates? In an attempt to anticipate this eventuality, the Survey is investigating a new approach to the control and attempted eradication of the cabbage maggot in Illinois. In 1955 entomologists of the United States Department of Agriculture invented a new type of insect control, directed against the screwworm fly, a destructive insect especially in Florida, Texas, and along the Gulf coast. Males were sterilized by exposure to radiation, then liberated in huge quantities in the field. They mated with wild females who then laid unfertilized eggs that did not develop. The screwworm fly has been virtually eliminated from the United States. Efforts to use this method on other species of insects have been stymied because we lack basic knowledge of their biology and habits, especially time and frequency of mating, and methods of sterilization without reducing the insect's competitive vigor.

Certain new chemicals may be a real help in such a program. A group of compounds called chemosterilants also produce various degrees of sterilization in insects and may offer a possibility of rearing sterilized males and females in sufficient numbers to swamp out normal males and females in the release area.

One of the big stumbling blocks to field use of these chemosterilants at the moment is our lack of knowledge of their effect on animals other than the insects.

Dr. Luckmann and his helpers are testing a chemosterilant called apholate, but, because this may be a potentially dangerous material, these tests will be rigorously confined to laboratory and cage experiments. Nothing tangible may develop from these chemosterilant experiments; on the other hand, they may lead to new horizons of insect control. The only way to find out is to try.

Raccoon in Illinois

A much-watched animal is the raccoon. Abundant in wooded areas and along streams throughout most of the state, it is a favorite game animal of many Illinois sportsmen and is also trapped extensively. In recent years, hunters and trappers in Illinois have harvested approximately 100,000 raccoons each season. A substantial portion of this harvest is sold as food for human consumption. Persons interested in the health of man and his domestic animals also watch the raccoon because it

is subject to a wide variety of diseases including pneumonia, infectious enteritis, canine distemper, rabies, and leptospirosis, some transmissible to man and domestic animals.

Raccoon populations in Illinois have undergone very peculiar changes. During the 1930's raccoons were at medium to low levels. In 1943 the raccoon population began to rise sharply. This rapid increase continued through 1946 and since then has oscillated around this new high. Survey wildlife specialist Dr. Glen C. Sanderson estimates that right now there are ten to fifteen times as many raccoons per square mile in Illinois as there were in 1930. The underlying reasons for this increase are only partially understood.

Because of the importance of the raccoon in Illinois and the serious gaps in our knowledge of its life history and habits, Dr. Sanderson undertook a study of its reproductive physiology. In a cooperative undertaking by the Survey and the U.S. Public Health Service, he has now studied these interesting animals for several years. He finds that the raccoons have their first sexual cycle of the season in February or March. If mated, in a little more than two months they give birth to one to seven young, usually three. If the young stay with the mother and nurse, the female does not have another sexual cycle until the next year. Dr. Sanderson has found, however, that if a female is not mated during the first sexual cycle, it goes through a period called pseudopregnancy which lasts as long as normal pregnancy. This pseudopregnancy is a peculiar phenomenon in that many of the internal organs actually develop as if the female were pregnant even though it is not, and the female does not have another reproductive cycle until a few weeks after the end of its pseudopregnancy. This time period totals about three months from the first reproductive cycle in late winter. Sometimes the mated females either lose their litter before birth or lose them immediately after birth. If so, unlike the females that nurse their young, they have another reproductive cycle at about the same time as the unmated pseudopregnant females.

Thus in May or June, the females unmated in their first sexual cycle of the season plus those females who lost their young either prematurely or at birth have a second sexual cycle and may produce litters in July or August. The young of the early season litters become practically full-grown by winter, but the young of the late season litters are only partially grown at first snow. Dr. Sanderson believes that, for a variety of reasons, these small immature raccoons have an unusually heavy winter mortality.

Obtaining an understanding of the "inner workings" of these animals should give us far better ideas than we have now concerning ways and means of keeping populations at optimum levels and thus avoiding the marked oscillations in numbers that normally have characterized these and other game species.

That Jaundiced Look

Landscapers and home-owners are often troubled because the leaves of some of their favorite trees become yellow. Sometimes this yellowing, called chlorosis, is

The tree-loving racoon. (Photo by W. E. Clark, former Survey photographer.)

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caused by disease or insect feeding. More often it is due to the deficiency of some nutrient chemical element such as nitrogen, phosphorus, iron, zinc, and several others. The actual mechanics of yellowing are very simple. Healthy leaves contain a mixture of both green and yellow pigments, the green pigment being chlorophyl, which is the main food producing pigment of the plant. Attacks by certain diseases and insects may destroy the green chlorophyl, and deficiencies of the chemical elements mentioned may leave the plant unable to manufacture chlorophyl. Under these circumstances, with the green color gone, the yellow pigment is the one that we see.

In Illinois the commonest type of deficiency leading to yellowing is the lack of available iron in the soil. Especially susceptible are oaks, especially pin oak, maples, and sweetgum; occasionally this condition occurs in other deciduous trees and in evergreens. Because the pin oak, one of Illinois' favorite shade trees, frequently fails to respond to treatment for chlorosis, Survey plant pathologist D. F. Schoeneweiss set out to discover why. In a series of experiments using red oaks, pin oaks, and grafted seedlings of pin oak scions on red oak rootstocks, Dr. Schoeneweiss found that the pin oak leaves were fully as efficient in utilizing iron in the manner of chlorophyl as were red oak leaves, but that pin oak roots were far less efficient in extracting iron from the soil than red oak roots. Both kinds of oak were normally able to extract plenty of iron from soils which were acid, but in soils that were alkaline both pin and red oaks were unable to get as much iron as they needed, even though the iron compounds were in the soil. In fairly alkaline soils red oaks showed a slightly chlorotic condition whereas pin oaks showed an extreme chlorosis.

Armed with this information, the Survey is now recommending that a combination of iron sulfate and sulfur be added to the soil around trees susceptible to chlorosis. The sulfur acidifies the soil and this makes the iron more soluble and more available to the plants.

This does not work rapidly but should stay effective for several years. Rapid but temporary cures are also available. More lengthy and detailed instruction for use of all these aids in overcoming chlorosis are available by writing to the Survey.

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The Illinois

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APRIL 1964, NO. 18

Report on the Elms

In 1950 Dutch elm disease of American elm was found in a single county of Illinois. A disease caused by a fungus either carried from tree to tree by a tiny bark beetle or passing from tree to tree directly through root grafts, Dutch elm disease had become the major shade tree problem in Illinois by 1954 and had spread into every county in the state by 1959. Controlling this disease has been extremely difficult. The best general control is expensive and must be applied rigorously to the entire elm population of an area. Considerable advances have been made in finding control measures that will work well under local or special situations, such as the iodine treatment of newly infected trees.

A major problem in studying control measures for this disease is the impossibility of conjuring up nicely spaced stands of 50- or 100-year-old trees where you would like to have them for a series of rigidly controlled experiments. Because of this, Survey pathologists studying the disease must rely on data from whole towns or cities, comparing conditions in those that have used different control measures or made no attempt at control. Survey plant pathologist Dan Neely has just completed this year's census of Illinois elms. The situation is as serious as ever. Throughout east central Illinois, less than 5 per cent of the original elm population has remained. Champaign-Urbana and Bloomington have now lost over 99 per cent of their elms. In southern Illinois, loss of elms seems to progress at a somewhat slower pace. This may be due to the sparseness of elms in this area, in turn due to the many elms killed earlier by the disease phloem necrosis. In the northern third of Illinois, where Dutch elm disease has spread within the last ten years, over half of the elms have been killed.

The only major area in Illinois where Dutch elm disease is being controlled is in the greater Chicago area. Approximately 40 municipalities or park districts in and around Chicago are practicing comprehensive disease control procedures and are maintaining low annual losses. Reports from 34 of these muncipalities show that

Applying potassium iodide to elm tree in early stage of infestation with Dutch elm disease. Survey plant pathologist E. B. Himelick is applying the poison.

the annual losses for eighteen were below 1 per cent; for eleven, between 1 and 2 per cent; for three, between 2 and 3 per cent; and for two, about 4 per cent. Comparable municipalities practicing no control had losses over 8 per cent.

Dr. Neely and his Survey colleagues now have available for distribution the detailed 1963 elm census and the best measures so far devised for control of Dutch elm disease.

All Steamed Up

Over the years, one of the most persistent pests of Illinois greenhouse crops has been the two-spotted spider mite. When abundant, this tiny mite defoliates roses, carnations, chrysanthemums, and several other favorite plants of the greenhouse trade. This crop totals no small figure. Every year in the 14 million sq. ft. under glass in Illinois, the growers raise over 10 million dollars worth of cut plants and 3 million dollars worth of potted plants, for an annual crop totalling 13 million dollars. The growers were therefore greatly concerned when, several years ago, spider mites became resistant to former control measures, at that time a group of compounds that were chiefly phosphorus compounds.

Survey entomologist L. L. English tested many new compounds on the mites and found that one called Pentac was unusually efficient. This is a double cyclic compound of carbon and chlorine that has the technical name bis (pentachlorocyclopentadienyl). Among the acarides, Pentac is also unusual because it has a low toxicity to warm-blooded animals and to plants, virtually eliminating hazards to the operator and the plants that are being protected.

Pentac is customarily applied as a spray, which is an expensive operation. Dr. English began experimenting with other means of applying the acaricide and found that it volatilized at about the temperature of operating greenhouses steam pipes. In experiments following up this lead, he found that a thin slurry of Pentac powder could be painted on steam pipes twice weekly for three weeks during the months when steam was turned on in the greenhouse, and the acaricide would volatilize and produce a complete kill of the mites. As with other fumigation treatments, the amount of acaricide applied to the pipes must be proportional to the cubic space of the greenhouse. Instructions for these dosages are available from the Natural History Survey.

For the Young

One of the most unexploited recreational opportunities in this country is the study of wild things. Nothing lends itself better to this activity than the moths and butterflies, of which we have probably 2,000 different kinds in Illinois, many of them large, beautifully patterned, and readily procured with simple equipment. Fascinating also are the larvae or caterpillars of these moths and butterflies, many of which can be found readily and reared easily, again with a minimum of equipment.

Attempting to develop this out-of-doors and do-it-with-your-own-hands recreation has long been a serious concern of the Survey, which has prepared circulars and movies in this field, especially for high school use.

Attempting to start the cycle at a lower age level, Survey editor J. S. Ayars and Survey entomologist M. W. Sanderson have converted some of their TV-viewing time into writing a brief account entitled *Butterflies, Skippers, and Moths* (published by Whitman Publishing Company), presenting an enchanting and easily understood introduction to the study of these gracious and intriguing insects. As the authors imply, this little book is designed for youngsters of any age from eight to eighty.

They've Got Grit

Certain peculiarities of the range of the ring-necked pheasant in the Midwest have puzzled wildlife investigators for years. Favorite of thousands of Illinois hunters, this bird has established self-maintaining populations south to about Brockton and Mason City but does not succeed below this line. In spite of repeated introduction, no permanent populations have become

Mr. Ayars and Dr. Sanderson comparing specimens of butterflies with pictures in their new beginner's manual.

established in the west-central and southern counties of Illinois.

Obviously something in the population cycle is not working properly. If a car isn't working well, one checks on various things that might be wrong — first the spark plugs, then the carburetor, then the valves, and so on — until the trouble is found. So it is with populations of wild animals. Known factors that are wrong frequently include lack of food, lack of water, lack of nesting sites, too many predators, and many other items in the natural environment which affect reproduction and survival of the species under study.

In Illinois, pheasants do well chiefly in the area covered by the most recent, or Wisconsinan, ice sheet, where relatively new soils have developed. The west central and southern areas of the state, where pheasants have never established themselves, are on areas of older soils. The questions arose: Are the newer soils richer in calcium and the older soils, that have been leached longer, poorer in calcium, and are the pheasants unable to maintain themselves on the older soils because of calcium deficiency?

To test this possibility, Survey wildlife researchers R. F. Labisky and J. A. Harper have made intensive studies of the calcium content of grit in soils from Neoga (an area of older soils) and from Sibley (an area of the most recent soils). In addition they have studied the feeding behavior of the birds in these areas. They found that the amount of calcium in the grit from both areas is very similar; thus, calcium was equally available to birds on both areas.

The amounts of calcium found in the grit from gizzards of hens and young from both areas were similar, indicating similar rates of ingestion. Also the number and hatchability of eggs per clutch, the production of chicks, and the mineral and calcium ash of hens were similar among pheasants on both areas. All this evidence suggests satisfactory ingestion and physiological utilization of calcium by pheasants on the older soils.

They found also that wild pheasants, particularly hens and young, have the ability to detect and choose grit high in calcium from grit low in calcium. This habit of selective calcium ingestion may allow pheasants to prosper on areas where calcareous grit is found only in relatively small quantities.

These studies have checked one facet of the natural environment and found that nothing seems to be wrong regarding the availability of calcium. Something else must be responsible for the failure of pheasants to become established in seemingly good pheasant habitat in portions of southern and western Illinois. Studies testing other factors of the environment are now in progress.

95% Clean Apple Club

Illinois' 15 million dollars-a-year fruit industry, consisting primarily of apples and peaches, is in the same position as the nursery business — its buying public demands an extremely high quality product. The old joke about "What is worse than finding a worm in an apple?" is no longer a joke. A few experiences with the proverbial "half a worm" finds the American housewife soundly berating the offending retailer. Nor will most consumers buy misshapen, blotchy, or blemished apples.

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A number of fungus diseases and a surprising number of different kinds of insects cause either external blemishes or some sort of a worm inside the apple. Constant vigilance and a complex control program must be carried out to provide attractive, worm-free apples. Responsibility for providing the information for the insect control lies with Survey entomologist Ron Meyer, stationed at Carbondale.

Realizing that premium prices go only with premium produce, 29 years ago the Illinois State Horticultural Society organized the 95% Clean Apple Club. Prime movers behind this action were Survey entomologist the late W. P. Flint and University of Illinois plant pathologist H. W. Anderson. Over the years this club has encouraged the growing of better quality fruit throughout the state, and used club membership to give public recognition to growers maintaining high standards of insect and disease control.

Last year, fruit from 41 of the 44 orchards applying for 95% Clean Apple Club membership were judged to be 95 per cent or more free of insect, mite, disease, and miscellaneous injury. This is the largest percentage membership since the club was started 29 years ago. This is gratifying testimony that not only are Dr. Meyer and his University of Illinois colleagues in plant pathology providing excellent recommendations concerning pesticides and practices but that the growers realize the value of using this advice and are following it wholeheartedly.

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MAY 1964, NO. 19

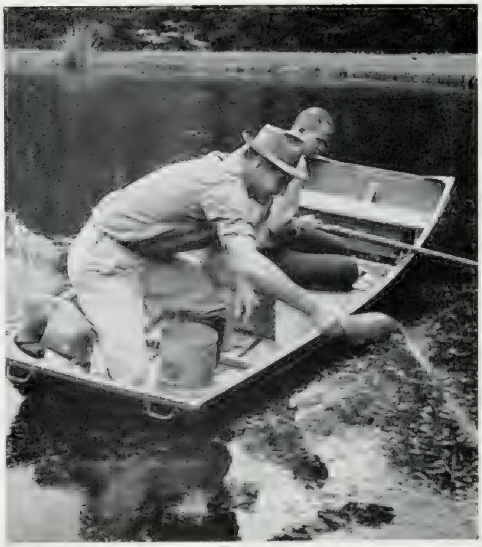
More Water "Weeds"

In many places our native water plants add a picturesque fringe to lakes and ponds. In water areas developed for boating, fishing, and swimming, these same plants may become so abundant that they foul propellers, snarl fishing lines, and make swimming virtually impossible. Survey biochemist R. C. Hiltibran found that many herbicides were highly effective in controlling emergent aquatic plants such as arrowhead, bulrush, waterwillow, and creeping waterprimrose.

Next Dr. Hiltibran and his crew turned their attention to the control of floating or submerged aquatic plants, starting with curlyleaf pondweed. They noted that the spring stand of this pondweed disappeared, followed by a new growth in late summer and fall. The appropriate time for elimination of the pondweed seemed therefore to be in the fall. Although several experimental compounds appeared to eliminate the fall stand, a new stand developed in the spring. The herbicide *endothal,* however, eliminated two stands of pondweed in 1960, 1961, and 1962, and only a few plants sprouted in 1963. It is estimated that these few plants can be controlled by local applications involving only little work.

Another aquatic plant difficult to control is the common duckweed. This plant is about the size of the head of a pencil, possesses great reproductive capacity, and apparently can grow to a mature seed-producing plant in a few days. This little plant increases with great rapidity and may cover the entire surface of a pond within a few weeks. For this reason complete eradication of the plant would be highly desirable. In none of the test plots, however, was this elimination obtained. Although *endothal* and *diquat* killed all the plants hit directly, dense duckweed bunches up so much that plants overlap each other and it is impossible to hit all of them. As a result, a single application of herbicide reduced the area of duckweed very drastically but left small nuclei that grew out again. Additional applications of herbicide made every two or three weeks, depending on the rapidity of duckweed growth, confined it to relatively small areas throughout the growing season.

Revised recommendations for formula-



Using a scoop, Dr. Hiltibran is applying experimental granular herbicides to floating mats of pondweed. Most herbicides are applied as a spray. (Photo by Survey photographer Wilmer Zehr.)

tions and dosages of acquatic herbicides are now available at the Survey.

Nature Preserves

Scientists and conservationists alike have been increasingly concerned with the disappearance of natural habitats in Illinois. Especially in the northern two-thirds of the State it is difficult to find virgin tracts of the varied and interesting habitats that made up primeval Illinois. Impelled by the need for preserving wild areas as tools for scientific study, as habitats for the preservation of wild species of interest to conservationists and naturalists, and as an enduring resource of natural areas for the benefit of future generations, the last General Assembly enacted far-seeing legislation to encourage the acquisition and maintenance of a system of natural preserves.

One bill established an Illinois Nature Preserves Commission of nine members, to be appointed by the governor on the advice of the chief of the Illinois Natural History Survey and the director of the Illinois State Museum. Representatives of the Department of Conservation, the Illinois Natural History Survey, and the Illinois State Museum will serve as advisers to the Commission but have no vote. In brief the powers and duties of the Commission are to:

- Approve or disapprove the acquisition or disposal by the Department of Conservation of nature preserves areas.
- Advise, approve, or disapprove concerning the management of such areas.
- Formulate policies for the selection, acquisition, management, and protection of nature preserves.
- Maintain registries and records of nature preserves and other areas of educational or scientific value and of habitats for rare and endangered species of plants and animals in the State.

In another bill, amendments to older legislation gave the Department of Conservation authorization, subject to the approval of the Illinois Nature Preserves Commission and of the governor, to acquire, by gift, purchase, grant, exchange, dedication, or condemnation, additions to the nature preserves system and to manage them in a manner approved by the Illinois Nature Preserves Commission.

Based on a list of candidates presented by Chief Mills and Director Thomson, Governor Kerner appointed the following Commission: Mr. James Brown IV, Dr. Margery C. Carlson, Mr. Elton Fawks, Mr. George B. Fell, Dr. S. Charles Kendeigh, Dr. Willard D. Klimstra, Mr. Edward M. Levin, Jr., Mr. Charles G. Sauers, and Mrs. Charles R. Walgreen. The Commission first met in Chicago on January 30, 1964, and elected Dr. Kendeigh as Chairman, Mr. Fawks as Vice Chairman, and Mr. Fell as Secretary.

Among the advisers attending the second meeting, held at the Sherman House in Chicago on March 19, were Dr. Mills and Survey botanist Robert Evers (author of the Survey's recent Biological Notes No. 50, *Some Unusual Natural Areas in Illinois and a Few of Their Plants*). Several areas were mentioned as possible nature preserves to be established under the system, and Dr. Evers was asked to examine some of them and report back to the Commission.

The Commission may be contacted through its chairman Dr. S. Charles Kendeigh, Department of Zoology, University of Illinois, Urbana.

Northward Ho!

After the first warming of spring-to-come, central Illinois is a passageway for millions of geese and ducks returning to summer breeding grounds to the north and northwest. Survey wildlife specialist Frank Bellrose reports that the first waterfowl responded this year as early as February 5, when a few pintails, shovelers, and canvasbacks made an appearance. However, it was not until late February that the spring flight began in earnest.

In the vanguard of northward-bound migrants were Canada geese, pintails, mallards, canvasbacks, and lesser scaups. The rear guard, departing in late April, embraced lesser scaups, ruddy ducks, and blue-winged teal. In between, several million ducks of some 20 species utilized the waters of Illinois for resting and feeding

One of the most exciting sights in the world — waterfowl rising into thunderous flight. Ducks rising from the marshes north of Havana, Illinois. (Photo by Survey editor J. S. Ayars.)

grounds as they headed for breeding marshes in the Dakotas, Manitoba, Saskatchewan, and the Northwest Territories of Canada.

This year, reports wildlifer Bellrose, ducks found spring feeding conditions in Illinois very unusual. Normally the Illinois, Mississippi, and Rock rivers overflow into bottom land cornfields, and in these temporary lakes and ponds the ducks find abundant food. This spring, however, little flooding occurred in the northern two-thirds of the state until after most waterfowl had departed. As a consequence, the birds concentrated on those more permanent lakes and sloughs that afforded even meager supplies of food. Fortunately for spring waterfowl, many acres of millet, smartweeds, nutgrasses, and the like were missed by birds during the fall, and these plants provided needed rations for tens of thousands of hungry ducks.

This year also the ducks were late. The unusually cool spring weather here and to the north arrested the northward surge of waterfowl. Radar surveillance disclosed few birds aloft on the many nights the wind blew from the north. On the few nights the wind blew from the south, waves of migrants arrived in central and northern Illinois.

One such occasion was March 12. During mid-day the wind shifted from north to south. That evening Lawrence Miller, U.S. Game Agent, witnessed the mass exodus of honkers from the Union County Wildlife Refuge, near Ware, Illinois. As he watched flock after flock of geese take off in northward flight, he observed other flocks of geese higher in the sky northbound from the Horseshoe Lake Refuge, 20 miles to the south. The whole flight totalled nearly 100,000 Canada geese. Departures continued into the night; by morning only a handful of geese remained where 140,000 had passed the winter.

This tremendous passage of Canada geese began to appear on the radarscope of the U.S. Weather Bureau's Chicago forecast center at 8 a.m., March 13. The flight, north to north-northeast over the Chicago region, reached a peak about 11 a.m. and subsided rapidly after 1 p.m. Targets on the radarscope showed flocks of geese spread over a front at least 90 miles wide from the Fox River to across Lake Michigan.

A late flight of ruddy ducks on the night of April 14–15 brought 20,000 of these perky birds to the Chautauqua National Wildlife Refuge, near Havana. This exceptionally large concentration did not tarry long; two days later most were gone.

Most ducks, returning to their ancestral potholes, ponds, and marshes on the northern plains, will not receive a hospitable homecoming. Despite late snows, the prolonged drought continues, and dust blows from the basins of innumerable ponds and marshes. About the only place returning ducks may find ample nesting sites is in western Manitoba and eastern Saskatchewan. So many water areas have evaporated elsewhere on the northern plains that many ducks will not even attempt to rear a family.

Tick and Chigger Warning

Now that spring is well advanced and more and more hikers are taking to the trails, Survey entomologist L. J. Stannard again warns out-of-doors enthusiasts to be on guard against wood ticks and chiggers.

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Wood ticks will be active from now until August, occasionally into September. They can transmit the parasite causing Rocky Mountain spotted fever which at some time or another has been detected in every county of the State.

Dr. Stannard cautions persons who will be out-of-doors in Illinois this spring and summer to remove all ticks from their person daily, preferably before the ticks settle down for feeding. Many of the wood ticks encountered may not be carrying fever-producing organisms, but potentially all can.

Chiggers will be out in southern Illinois from about mid-May until early October, in the northern half of the state from early June until late September or early October. The smallest native ectoparasite that bothers man in our State, the chigger is many times smaller than the head of a pin and even slightly smaller than the period at the end of this sentence. Birds and reptiles are the natural hosts of many chiggers but man can also be attacked. Of the more than 40 species of chiggers occuring in Illinois, Dr. Stannard finds that only one, called *Trombicula alfreddugesi,* is troublesome to man and occasionally to domestic livestock.

Preventive measures are considered the best protection against chiggers. Survey entomologist W. N. Bruce recommends that commercial repellants containing benzol benzoate or diethyl toluamide be rubbed on the feet and legs, under the belt line, and around the groin each day before going into fields or woods. A solution containing one part benzol benzoate in nine parts of light mineral oil is particularly effective for this purpose and can be prepared easily. Taken at certain doses, drugs used for some other human allergies can also alleviate the itching caused by chigger bites.

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JUNE 1964, NO. 20

Alfalfa Gourmet Club

For the first 50 years of this century alfalfa growers of the west fought the ravages of a little gray-brown insect one-fifth inch long called the alfalfa weevil, accidentally imported from southern Europe at the turn of the century. As the years rolled by and the weevil increased but remained restricted to the west, it looked as if the weevil perhaps could not survive in the climates of eastern North America.

First specimens of the alfalfa weevil found in Illinois. Above, the greenish larva and below, the grayish adult.

In 1952 this eastern dream ended. That year the alfalfa weevil popped up in Maryland and nearby states. In 1959 it was in eastern Kentucky. Last year it reached eastern Arkansas. This year, on April 24, Survey entomologist R. J. Dysart found a few weevils in alfalfa fields in Hardin County. Intensive search aided by fellow entomologist C. E. White shows the weevil in 20 southern Illinois counties.

According to head Survey entomologist George C. Decker, the weevil is not yet present on individual farms in sufficient numbers to justify the expense of control measures. "The history of the alfalfa weevil in other states indicates that it may take two to four years for infestations to build up to economic proportions," says Dr. Decker. "After that time, without suitable control measures, alfalfa production becomes practically impossible."

The weevils winter in the adult stage under leaves and rubbish in the vicinity of the alfalfa field. They come out of hibernation in spring, feed a few days, mate, and the females lay their tiny, oval, yellowish eggs in the stems of the alfalfa. This egg-laying process is unusual. The chewing mouthparts of the females are at the end of a long beak. Using this beak, the female first eats out a deep cavity in the alfalfa stem and then inserts one to many eggs in each. Each female lays from 600 to 800 eggs during the spring. In warm weather these hatch in about 10 days into greenish larvae that move to the tops of the plant and feed on the foliage for three or four weeks. When full grown,

the larvae descend to the surface of the soil and spin a cocoon in which they pupate. In about 10 days the adults emerge. These feed, but not as voraciously as the larvae. The adults live from 10 to 14 months, and there is sometimes a second partial generation in a year.

Plotting the spread of this weevil is extremely difficult. Survey taxonomist M. W. Sanderson points out that two other very similar weevils already occur in the state, both primarily feeding on other clovers but also occurring in small numbers on alfalfa. No characters are yet known to identify the early larval stages of these three weevils and Dr. Sanderson is now searching for such identification aids. In the meantime Dr. Dysart and his colleagues are keeping a close watch on the weevil in order to predict when and where control measures will be necessary.

Moving Day

After five profitable years of sport fisheries investigations at the McGraw Wildlife Foundation ponds at Dundee, aquatic biologists George W. Bennett and Homer D. Buck are moving the Survey's pond research to a new base. This is a set of nine one-acre ponds, planned by Director William T. Lodge and Executive Assistant Sam A. Parr of the Department of Conservation, and constructed to exacting specifications by the Department in the new Stephen A. Forbes State Park near Salem.

Typical of most Illinois farm ponds and small recreational lakes, this experimental fish farm should give answers to many questions about stocking and managing Illinois waters with the commoner warm water sports fish — bass, bluegills and other sunfishes, and some catfishes. This is the ultimate aim of the program, sponsored jointly by the Department of Conservation and the Natural History Survey. Dr. Bennett points out, however, that during the first year all ponds must be stocked and treated alike to find out if certain ponds have unforeseen peculiarities that, undetected, might later lead to false conclusions.

Dr. Buck, project leader of the operation, and assistant project leader Charles F. Thoits are now filling the ponds, adding the first test species (carp, because it is omnivorous), trouble shooting the mechanical problems that always hound a new installation, and getting ready to take notes.

Hungry Horde

In Illinois today farming is not just an occupation, it is a business run on as tight a financial basis as any other kind of business. Everything must be done to insure a crop, and one of the primary activities is to protect it from ravages of insects. Not every acre needs treating every year, but when certain acreages do need treating, this must often be done exactly and promptly to insure against disastrous losses.

As in past years, the Natural History Survey and the University of Illinois Experiment Station have cooperated, first in making control recommendations throughout the season, then in assembling and summarizing figures on the number of acres of various crops that were treated with insecticides and the estimated value of these measures in terms of profit to the farmer. Entomologist H. B. Petty and his associates have completed this summarization for the more common insect pests of

Acres of Field Crops Treated with Insecticides and Estimated Profit from Treatment, Illinois, 1963

Crop and Insect	*Acres Treated*	*Estimated Profit**
Clover and alfalfa		
Cloverleaf weevil	20,934	$ 31,401
Potato leafhopper	30,433	60,866
Meadow spittlebug	19,467	19,467
Sweet clover weevil	30,563	244,504
Pea aphid	13,925	20,888
Corn		
Soil treatment	4,049,318	16,197,272
Cutworm	421,231	2,106,155
European corn borer	311,346	1,245,384
General		
Grasshopper	672,433	3,025,948
True armyworm	245,547	245,547
Total	5,815,197	$23,197,432

* Over and above treatment costs.

Inspecting the first completed and filled 1-acre experimental pond at Stephen A. Forbes State Park. From left to right, Harlow B. Mills, Sam A. Parr, William T. Lodge, George W. Bennett, Homer D. Buck, and Charles F. Thoits checking the finished product against the blueprints. (Photo by Survey photographer Wilmer Zehr.)

important field crops from information supplied largely by Illinois farm advisers. These values, given in the preceding table, represent only a fraction of the total value of insecticide usage in Illinois because they refer only to a limited number of insect pest species and to only a few groups.

In other ways Survey entomologists save the Illinois farmer at least an equal amount of money. Through their weekly survey of the abundance of injurious insects throughout the state, these men provide farmers in pertinent areas with firm assurance that certain crops *do not* need to be sprayed because insect pests in their regions are not sufficiently abundant for control measures to be profitable. The abundance of these pests is intimately associated with weather conditions during all stages of their life histories. Because weather is highly irregular over the state, certain kinds of pests may be abundant in one part of Illinois and scarce in others.

It costs about $1.50 per acre to treat field crops with one average insecticide treatment. The savings to farmers by being informed when not to treat produces an estimated savings of about 20 million dollars per year.

Reproductive Phenomenon

Considering all its toll-taking enemies — dogs, cats, foxes, hawks, diseases, hunters, automobiles — it seems almost mystic that cottontail rabbits remain the most abundant wild game animal in Illinois. Yet that this is true is well attested by the cottontail's topping the list in the hunter's bag every year.

Seeking better information on cottontail reproductive capacity, Survey wildlife researcher D. A. Casteel constructed special ½-acre pens in which individual cottontails could be studied in detail but still in essentially natural conditions. The findings were phenomenal. After giving birth to her litter, the doe has a new reproductive cycle immediately, and normally breeds from seconds to minutes after parturition. In about 28 days a new litter arrives and

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the cycle begins again. Thus from late February or early March to late August or early September a doe rabbit is pregnant every day. Only in late fall and winter is the cycle interrupted.

How soon after birth do rabbits reproduce? To this question Survey wildlifer W. Edwards sought better information. That young-of-the-year doe cottontails produce young during their first summer had been well established for some time. Preliminary analysis of the Edwards data gives more specific indications. It now appears that young does that attain an age of 80 or 90 days by July 1 normally reproduce during their first year, and may conceive at least two litters. Young cottontail does that reach this age later in the year are apparently incapable of reproducing until the next February.

All in all, the cottontail is reproductively geared to the utmost to keep up with its enemies.

High Sap Pressure

Like people and the common cold, trees have some diseases that seem to be always with them. Chronic among these is the wetwood disease caused by bacterial infections. Although this disease occurs in many kinds of trees, including apple, birch, hemlock, hickory, linden, and sycamore, it is most prevalent in elms, especially the Siberian elm. When chronic, wetwood causes wilting of foliage, oozing of fermented sap through trunk wounds, and contributes to the general decline of the affected trees. An unusual manifestation is the very high internal pressures which develop inside the trees if no escape holes are available. The gas liberated in the wood by the action of the bacteria may reach pressures as high as 60 pounds per square inch. Sap accumulating under pressure in the diseased wood produces the water-soaked condition that gives the disease its name *wetwood*. The disease was poorly understood until 1945 when Survey plant pathologist J. C. Carter performed the classic study on the wetwood disease of elms that gave new insights into the disease and its alleviation, for which he received the National Arborist Association award for outstanding research on shade tree preservation.

Dr. Carter has revised his previous treatment of wetwood disease and what can be done about it. This is now available as Circular 50 of the Illinois Natural History Survey, from which it may be obtained on request.

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JULY 1964 NO. 21

Welcome Aboard

This time it is a real pleasure to announce the introduction of two foreign insects into Illinois. Late this spring two kinds of wasps were sent to Illinois by special air mail arrangements and liberated in the state.

The first of these was a little Japanese wasp about one-half-inch long called *Tiphia vernalis.* The *Tiphia* females search through the soil until they find a grub of a Japanese beetle or other scarab, sting and paralyze the grub, then lay an egg on it. The egg hatches into a wasp grub and proceeds to eat up the beetle grub. When full grown, the wasp grub spins itself a cocoon, pupates, and the adult emerges from this cocoon to start the cycle all over again.

Dr. Luckmann (above) releasing live Tiphia wasps (below) near Mattoon, Illinois. (Photo by Survey photographer Wilmer Zehr.)

The U.S. Department of Agriculture has imported and tested many kinds of *Tiphia* wasps in the eastern states in the fight against the Japanese beetle. Of all the kinds of wasps tested, this particular one gives the greatest promise of establishing itself and reducing Japanese beetle populations. U.S.D.A. biologists sent one shipment of *Tiphia* wasps to Survey entomologist W. H. Luckmann, who released them north of Mattoon where a new infestation of Japanese beetles was found last year. A large shipment was sent to U.S.D.A. biologist R. W. Bills, who released them in various localities in Indiana, including the Kentland area adjacent to the Illinois line, in the heart of the area near Sheldon, Illinois, heavily infested with Japanese beetles.

The other wasp is a real tiny fellow about one-sixteenth of an inch long called *Tetrastichus incertus.* This little gem parasitises the alfalfa weevil that recently reached Illinois (see June *Reports*). Originally spotted by the European parasite laboratory in France, U.S.D.A. entomologists have propagated this species in their extensive laboratories at Moorestown, N.J., and last month sent 1,900 specimens to Survey entomologist R. J. Dysart, who released them in five southern Illinois

counties where alfalfa weevil infestations had become established. The little *Tetrastichus* female, many times smaller than the alfalfa weevil larva or grub, flies around the alfalfa plant until she spots a weevil grub, then alights, inserts her ovipositor into the grub and lays as many as 20 eggs into the hapless larva. These eggs hatch and the parasites live on the body contents of the weevil larva, killing it. The full grown wasp larvae pupate inside the dead weevil larva and emerge as adults about two weeks after the eggs were originally laid.

Dr. Luckmann and Dr. Dysart will be following the success of their two "charges" in the coming seasons. Let us hope these two imported insect friends thrive.

Dog-leg

When the duck hunters put away their guns at the end of the season and stories of hits and near hits gradually fade from the conversation, Survey wildlife specialist Frank Bellrose and his crew start their most serious work with the ducks. This is the time that their radar pictures are assembled and enlarged, distances measured with calipers, and numbers, angles, dots, and dashes are fed into calculating machines, organized to ask those radar pictures questions about ducks.

In checking directions of the 1963 southward migration of ducks, wildlifer Bellrose was amazed to discover that there were two distinct patterns of duck migration. Ducks west of Des Moines, Iowa, were flying on a southeasterly course from central Saskatchewan and Manitoba. Not so the ducks that use the lower Mississippi flyway. They started from the north on a southeasterly course but somewhere between the level of Des Moines, Iowa, and St. Louis, Missouri, altered their direction of migration to almost true south. This direction they held until they reached their wintering grounds in the marshes along the Gulf Coast. Other migrating ducks still flew southeastward at St. Louis, Little Rock, and Evansville, apparently having maintained this same general direction all the way from their Great Plains breeding grounds.

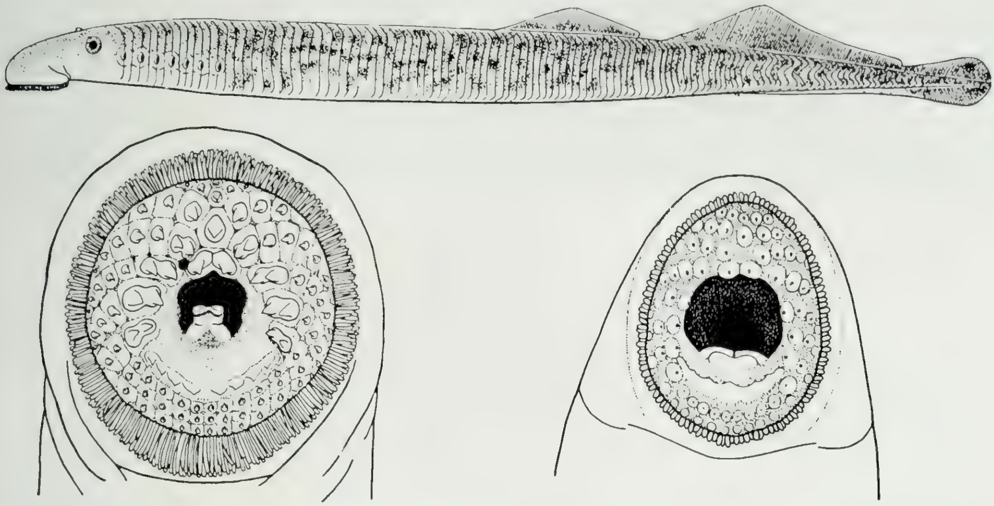
In each flyway, flock after flock of birds followed the same pattern. From banding and trapping, the Survey's duck crew had already discovered that each individual flock consisted of a mixture of old and new birds. Adding this knowledge to the flight pattern, it seems certain that each flock is led by old birds who know their route with amazing accuracy. The young birds in the flock must also be quick to sense landmarks and navigational guides because the old birds of this year's flock are the young birds of only a few years ago.

Lampreys

Two decades ago, to most Illinoisans the word "lamprey" meant a three-letter word in a crossword puzzle. Those addicted to working puzzles automatically filled in the blank spaces with the word "eel." In the last few years the word has had a different meaning, for this animal has been publicly accused of destroying the Great Lakes fishery.

The lamprey is neither eel nor fish. It belongs to an ancient and nearly extinct group of primitive but highly modified vertebrate (back-boned) animals that came on the scene millions of years before the hinged jaws of fishes and higher vertebrates had evolved. The lamprey is most easily distinguished from a fish by its snake-like body, sucking disk mouth, seven separate gill slits on each side, and its single nostril situated on the midline. The largest species may reach a length of two feet; most of them are much shorter.

Illinois has not one but five different kinds of lampreys. Three of them, including the destructive sea lamprey, are parasitic and attach themselves to the bodies of fishes as blood suckers. Although lampreys normally do not kill their hosts, their feeding causes so much tissue damage and loss of body fluids that it weakens the fish and makes them more susceptible to infection. The other kinds of Illinois lampreys are nonparasitic and quite harmless. All lampreys spawn in fast gravelly riffles. The egg hatches into a larval stage known as an *ammocoete,* which remains in the gravel, feeding on plankton that it strains through its sievelike mouth. Most species



Sea lamprey (above), enlarged view of sucking disk mouth and large rasping teeth shown at lower left. At lower right is the disk mouth of the nonparasitic brook lamprey. (Drawings by Survey artist Mrs. Alice Prickett.)

transform to the mature adult in a few months but the sea lamprey requires several years. Adults of parasitic species attach to fish; adults of nonparasitic species do not feed at all.

In the late 1940's Survey aquatic biologist Dr. William C. Starrett became concerned that the dreaded sea lamprey, which had recently invaded lakes Huron, Michigan, and Superior in enormous numbers, might continue its inland invasion and pose a threat to the commercial fishing industry of Illinois' large rivers. He knew that this lamprey had been able to bypass a natural barrier (the Niagara Escarpment) with the completion of the Welland Canal in 1824 and that it had only recently spread into the western Great Lakes. Fearing that it might utilize the barge canals to enter the Illinois and Mississippi rivers, he solicited the aid of the State Department of Conservation and of many commercial fishermen along Illinois' large rivers. Over a ten-year period, 454 specimens of parasitic lampreys were collected. Fortunately all but one turned out to be native species that apparently do little damage to the fishing industry, and the one sea lamprey taken, allegedly from the Du Page River, was believed to have actually been found in Lake Michigan. Copies of the report on the native Illinois lampreys by Dr. Starrett and his associates may be obtained by writing the Survey.

Surveillance of the lamprey situation by Dr. Starrett and Survey ichthyologist Dr. Philip W. Smith continues, but it is not likely that the sea lamprey will ever threaten the river fishery of Illinois. A poison has recently been found that kills lamprey ammocoetes but does not harm other aquatic organisms. Use of this selective poison in tributaries of the Great Lakes by U.S. and Canadian officials is seemingly bringing the sea lamprey under control.

Information Retrieval System

Biologists in a research-service organization like the Natural History Survey may be confronted any day with the necessity for identifying any one of the 30,000 different kinds of plants or animals normally occurring in a state like Illinois, then knowing many things about this species — where does it live, is it harmful or beneficial, how abundant might it get, how many generations a year does it have, how can it be controlled? If the species is a newly introduced one, it might be any one of the other 1,500,000 species of living things known from other parts of the

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world. It is impossible for the scientists in any state or country to find out all these things by their own investigation. They must use scientific findings published in many languages and journals throughout the world.

Extracting information from this huge mass of literature is a real problem. The common names that we give to organisms are highly unsatisfactory as the basis for an extracting index. For example, the English robin is a very different little creature from the American bird we call a robin; our robin is little more than a color variant of what the English call a blackbird. What we call a blackbird in this country doesn't occur in England. An insect known as the cotton ~~leaf~~worm in the southern states is called the corn earworm in the northern states.

Over 200 years ago, students started using a type of shorthand for the then extremely cumbersome naming system, using long descriptions as the names of different kinds of plants and animals. The student shorthand became stabilized in 1758 into a two-name or binomial system by which each different kind of living thing was known by two Latin names, one called the genus, the other the species. By this system, the name of the housefly is *Musca domestica*. This is the official scientific name used for this particular kind of insect throughout the world, no matter in what language the paper is written. These Latin or latinized scientific names are the basis of the various indexes summarizing known biological knowledge, and are therefore the root of a tremendous information retrieval system.

This month, in company with about 2,000 fellow scientists from all parts of the world, three Survey entomologists, G. C. Decker, J. H. Bigger, and H. H. Ross, will be attending the International Entomological Congress in London. There they will be either adding material to, extracting material from, or making modifications to this information retrieval system as it applies to the million or more kinds of insects.

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NATURAL HISTORY SURVEY REPORTS

AUGUST 1964, NO. 22

Honeylocust Eater

After enjoying years of freedom from unsightly diseases and pests, Illinois honeylocusts are now being attacked increasingly by a tiny moth called *Homodaula albizziae,* or the mimosa webworm.

It was first discovered on this continent in 1940 defoliating mimosa trees in Washington, D.C. Apparently it was accidentally introduced from the Indo-Australian region, the native land of the mimosa tree. The insects spread westward, reaching Metropolis, Illinois, in 1957. Since then it has spread northward, now being common in the southern two-thirds of the state with occasional records as far north as Grundy and Cook counties.

The mimosa webworm. *Above,* honeylocust showing nests made by larvae; *left below,* adult moth; *right below,* full grown caterpillar.

The most characteristic evidence of mimosa webworm infestation is the presence of their nests, composed of leaves webbed together in a compact cluster. The leaves soon dry and turn brown due to the webworm feeding. The webworm caterpillars are small and slender, about one-half-inch long, dark gray to brownish in color, and have whitish longitudinal stripes on the back. When a nest is pulled open, the larvae react with quick jerky motions.

The moth is about one-quarter-inch long, mouse-gray with small black flecks on the wings. The pupae are formed in the nests or in surface litter near the base of the host tree. The species overwinters in the pupal stage. Adults start emerging and laying eggs on the foliage in early June in central Illinois, continuing well into July. Damage begins to show up about a month after the first adults appear and increases rapidly so that in two or three weeks trees appear heavily infested. Two broods and a partial third occur here, the second generation reaching a peak in late August.

Although mimosa trees appear to be its original host, the webworm has transferred successfully to honeylocust, especially moraine locust, on which it is a voracious feeder. Heavy infestations may completely

defoliate a small tree. Although the trees are not killed, repeated defoliation damages a tree and stunts its growth. Trees should be inspected frequently during June and July and upon the first appearance of nests control operations should be commenced. Control recommendations may be obtained from the Illinois Natural History Survey.

Duck Detectives

One of the most exciting break-throughs in Survey studies of duck migration has been the relation between flight speed of ducks and wind velocity. The Survey's duck specialist Frank Bellrose recently completed the analysis of 4,133 migration speed records of ducks during their 1963 southward migration. These records were taken from radar photographs made at Havana and Urbana, Illinois, by Richard Graber and Frank Bellrose in the course of their cooperative studies. Each frame of photographic film was exposed for a period of two minutes during which the radarscope was making continuous circle sweeps. The radar beam was tilted at an angle of 45° and the beam itself was a 3° cone of radar impulses extending out like the beams of a flashlight up into the sky. Any bird situated within certain favorable portions of this beam registered on the negative as one dot in each sweep. Each sweep of a complete circle took six seconds. It was therefore possible for a bird to register on the negative as a series of dots, sometimes in a curve, sometimes in a straight line. From these dots the bird's direction of flight could be calculated.

Any dots in a straight line represented a six-second interval from dot to dot. By calculating the distance of the bird from the radarscope it was possible to calculate how far it had flown in six seconds and from this to calculate its speed.

To everyone's surprise it was discovered that the ground speed of the migrants was remarkably unvarying regardless of wind direction and velocity. In other words, the birds flew at the same speed in relation to the ground whether they were being assisted or hindered by the wind. The only explanation seems to be that birds sense a head-wind and expend more energy, and likewise sense a tail-wind and reduce their flight efforts to compensate for it. Weak-winged flyers apparently recognize that strong winds are hazardous for migration and do not migrate when strong winds occur. On the other hand, strong-winged flyers apparently recognize the assistance provided by strong winds and select times and altitudes at which they prevail.

Other ways of "reading" the radarscope pictures offer good evidence that ducks aloft are capable of distinguishing not only velocity but direction of wind. If it should prove that ducks and other birds are able to determine precisely the movements of air, this ability might well be a directional cue in their navigation. Should this be substantiated, we may discover that air currents may rival the sun and stars as navigational aids for migrating birds.

Poisonous Snakes

Most of us can tramp the woods and fields of Illinois for years and never see a poisonous snake. To Survey taxonomist Philip W. Smith finding these animals is not difficult. Knowing their haunts and habits, he can locate them with unerring accuracy if they are around.

Four kinds of poisonous snakes occur in Illinois. Listed in order from the largest, and therefore the most dangerous, to the smallest and least dangerous, they are the timber rattlesnake, cottonmouth or water moccasin, copperhead, and massasauga rattlesnake. In most Illinois counties they still occur, but so rarely that the killing of a poisonous snake is a news item for the local paper; in a few counties one or more species may be locally common.

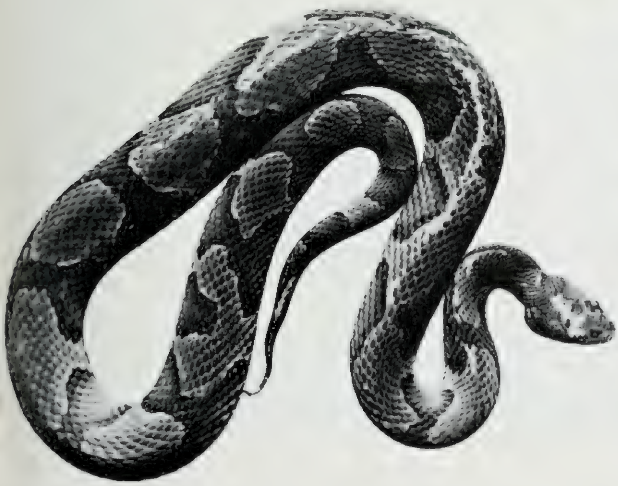
Venomous snakes may be found in a few other counties, where we have no record of their present occurrence, although to date all of the presumed poisonous snakes sent or brought to the Natural History Survey for positive identification have turned out to be harmless species. Contrary to the widely held belief, head shape and size are not easy ways to distinguish a poisonous from a harmless kind. The four dangerous species can be recog-

Illinois' Four Poisonous Snakes

The massasauga rattlesnake, a small species chiefly in prairie or marsh areas.

Above, the timber rattlesnake, restricted largely to rocky wooded regions.

Below, the copperhead, in wooded rocky areas only in the southern half of Illinois.



The water moccasin, chiefly a flood plain or marsh species in southern Illinois.

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nized with certainty by the long hollow fangs, a deep pit between the eye and nostril on each side of the head, a vertically elliptical pupil in the eye, and a single row of plates on the underside of the tail. All harmless snakes in Illinois lack fangs and facial pits and have round pupils and a double row of plates under the tail. The two rattlesnakes are readily identified by the telltale and conspicuous rattles on the end of the tail. A snake with a stumpy tail is almost certainly not a rattler, and one that produces a buzzing noise by vibrating its tail tip in leaves is not necessarily one.

All of the features just mentioned require rather close scrutiny and are therefore practical only if the snake is dead. However, each of the four species has a distinctive pattern that the camper, picnicker, sportsman, and mushroom hunter can quickly learn to recognize. These are illustrated in Dr. Smith's article *Some Facts about Illinois Snakes and Their Control* (Survey Biological Notes No. 32). Because this publication is out of print we are here reproducing pictures of the four poisonous snakes as a service to our readers until Dr. Smith's publication is again available.

Even in areas where venomous snakes are known to occur, they seemingly pose no threat to outdoor recreation, if a reasonable amount of caution is exercised. The best remedy for snakebite is to avoid being bitten in the first place and requires only that one watch where he steps and places his hands. Nearly all instances of snakebite that have come to our attention have been the result of amateur herpetologists becoming careless while trying to capture the snake. Should a person be bitten, however, he should avoid exertion and stimulants so that blood circulation is not increased, and keep in mind that the possibility of death is extremely remote. Obviously he should have medical attention as soon as possible.

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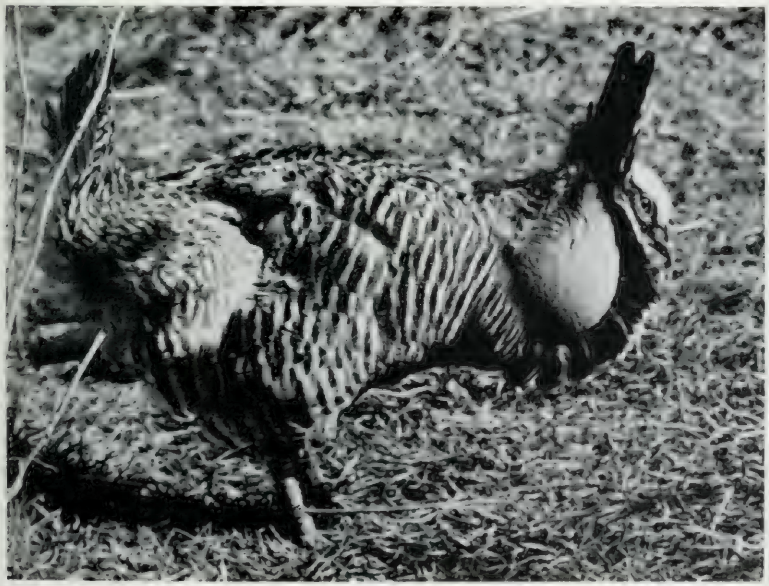
SEPTEMBER 1964, NO. 23

Back to the Wall

Farmers living in south-central Illinois enjoy telling of large numbers of prairie chickens on or near their farms twenty to thirty years ago. They speak of enjoyable chicken hunts before that when there was a prairie chicken hunting season. Likewise, they describe watching the colorful courtship displays which occurred each spring. In time, though, they come to the question, "Why did they die out?"

Prairie chickens have "died out" in much of their former range in Illinois. Even where they are now found, their numbers represent a small fraction of those present only twenty-five years ago. Dr. Ralph E. Yeatter, now retired from the Illinois Natural History Survey, recorded the decline of prairie chicken numbers on a four-square-mile study area near Hunt in Jasper County. In 1936 Dr. Yeatter counted seventy-six males on the mating or "booming" grounds on the Hunt area. By 1963 he could find only four males on these booming grounds. He attributed this decline of prairie chickens primarily to a loss of nesting and brood cover. What Dr. Yeatter described as happening at Hunt, we now know was occurring over most of the prairie chicken range in Illinois. According to a census conducted by Ralph J. Ellis, biologist for the Department of Conservation and the Natural History Survey, only about 2,000 prairie chickens remained in Illinois in the fall of 1962. Recent research by Ellis and other personnel of the Natural History Survey re-



Male prairie chicken showing the large sac (under the tall comb) that is extruded when the bird makes its booming sound. (Photo by Survey personnel.)

vealed that prairie chicken numbers in Illinois were further reduced by approximately 19 percent between April 1963 and April 1964.

As reported in our December 1962 *Reports,* nature lovers from many organizations formed the Prairie Chicken Foundation of Illinois for the purpose of purchasing Illinois preserves where prairie chicken populations would persist. The first of these, the seventy-seven-acre Yeatter Sanctuary, near Newton in Jasper County, was purchased in 1962. Next came the question: Would prairie chickens build up permanent populations on these small areas? To get an answer to this question, biologist Ellis has been studying the success of the birds in the Newton refuge. During the 1964 nesting season he found fifteen nests on this seventy-seven acres, an unheard-of nesting density for this species. Thirteen of the fifteen nests were apparently successful and two were destroyed by hogs that broke through the fence into the sanctuary. Most of the nests were established on windrows left from combining redtop seed during the fall of 1963. Ellis's research indicates a base of dry vegetation is desirable, and may be essential, for the prairie chicken to nest successfully.

These findings demonstrate to a striking degree the ability of this native Illinois prairie grouse to survive if given a chance. This chance, however, must depend on obtaining many more refuges for these birds. The Prairie Chicken Foundation has added eighty more acres of refuge in Jasper County, but as Foundation Treasurer Fred C. Pullman points out, this is scarcely enough to assure the security of the flock near Newton. Obtaining additional sanctuaries is becoming increasingly important because a large proportion of the nesting and brood cover for Illinois' prairie chickens has been on Federal Conservation Reserve acreages that will nearly all be cropped or grazed by 1965.

Continued research on the management of prairie chickens on small acreages is undoubtedly a necessity for maintaining the birds on sanctuaries, but unless by some means the sanctuaries are provided, it seems certain that there will soon be no prairie chickens in Illinois.

". . . eating my beans!"

Every day worried people write to the Survey reporting that insects are eating their corn, soybeans, phlox, lawn, shrubs, or trees. Often the only insect stages present are little caterpillars, grubs, or nymphs that are extremely difficult, if not almost impossible, to identify. Because an assessment of potential damage and, where indicated, the recommendation of a specific control measure depends on identifying the insect, these problems of indentification pose a real headache to Survey insect taxonomists.

Although many kinds of insects feed on many different kinds of plants the great proportion of insect species feed on only a few closely related kinds. Thus some feed only on oats or wheat, others only on clover, others on phlox, etc. The plant on which the insect is feeding is therefore sometimes the best clue in trying to find out what it is. Over the years entomologists have studied the insects on specific hosts and published reports of their findings.

Realizing the potential value of these host-insect compilations, Survey entomologist M. W. Sanderson started bringing together these publications but found that it was a difficult job because many highly useful papers had been published in obscure journals and never incorporated into an organized body of information. By 1962 Dr. Sanderson and his colleague Dr. J. M. Kingsolver had located about 400 useful references and these were published as a number of the Survey's "F" series as a progress report entitled "A Selected Bibliography of Insect–Vascular Plant Associations in the United States and Canada." The references are listed by plant families for easy reference, together with other useful information about the feeding habits of major groups of insects.

This experimental bibliography proved so useful that our limited original edition was exhausted in a few weeks. Entomologists and botanists were unanimous in re-

Department of Conservation biologists Paul J. Vidal and Leo F. Rock maneuvering the otter trawl in Lake Michigan near Winthrop Harbor. (Photo by A. C. Lopinot, Department of Conservation.)

questing a more extended bibliography and many of them cooperated in locating additional useful items. Even with these additions, the number of important plants for which we need the insect host data collated is a real eye-opener and it is to be hoped that this initial compilation will serve as a stimulus to entomologists to bring together more of the highly useful host references.

In spite of its preliminary nature, Dr. Sanderson and Dr. Kingsolver (the latter in his new position with the USDA) have been encouraged to revise their material immediately and the USDA has agreed to publish the new and enlarged edition of their bibliography. It will bear the same title and will appear in USDA series E.

Cool-Water Fishing

Our knowledge of the fishes in the Illinois waters of Lake Michigan is scanty. Especially is this true of the small fishes that are not caught in the larger mesh nets of commercial fishermen. The paucity of this knowledge is readily explained — large nets must be used, and these require good boats and experienced crews to handle them. The weather is often uncooperative; these large nets cannot be handled well in rough waters.

In order to compare Lake Michigan fishes with those in other Illinois lakes and streams, Survey ichthiologist P. W. Smith and the Department of Conservation's Chief Fishery Biologist A. C. Lopinot combined their efforts to find out the species, composition, and relative abundance of fishes along the shore line of Lake Michigan. The Department of Conservation brought in two of their power boats and some of their larger nets, and procedures were devised for sampling the lake with the small-mesh otter trawl and the bag seine. Authorities of the cities of Winthrop Harbor, Waukegan, North Chicago, Lake Forest, Highland Park, Evanston, and Chicago kindly granted permission to use launch facilities and to work in their portions of the lake.

Collections were made at eleven stations in the approximately sixty miles of lake front between the Wisconsin and Indiana state lines. The otter trawl, which had a small-mesh cod section, was dragged over the bottom by an 18 HP boat in water ranging from three to thirty feet in depth. Simultaneously the bag seine was employed by another crew along the beach at each station.

The fish were far from abundant. The 900 specimens collected represented many

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a bent back; hauling in a long seine is hard work. The fish were preserved as collected and brought back to the Survey laboratory for sorting and identification. Altogether nineteen different kinds of fishes were taken. The proportions of these were entirely different from those previously reported, raising interesting questions hinting at either unknown seasonal changes in Lake Michigan fishes or overall changes in the fish fauna during recent years.

Tree Doctor

Growing a tree, like raising a child, takes so long that we feel a genuine sentimental attachment for the oaks, lindens, sycamores, and their kin that grace our gardens, streets, and parks. When sickness strikes our trees we are doubly concerned, first, because there seldom seems to be an obvious cause and, second, because there often seems little that can be done about it. More can be done about tree diseases than most people realize, and this information is contained in the Survey's Circular 46, *Illinois Trees: Their Diseases,* recently revised by Survey plant pathologist J. C. Carter.

About twenty-three species of native and naturalized trees highly prized in Illinois as street, garden, and park species are commonly attacked by over forty-five diseases affecting the leaves, stems, and the vascular tissues that transport water and nutrients up and down the trunk and larger limbs. Trees are most often killed by vascular diseases and of these Verticillium wilt attacks more kinds of trees than any other single disease.

In this third printing of Circular 46, Dr. Carter explains the different types of tree diseases, the fungicides used in their control, and general care of trees including feeding, watering, pruning, sanitation, and wound treatment. A second part includes specific information on the symptoms and control of the diseases more frequently found on Illinois' most used trees. A third part that should be consulted by anyone contemplating extensive tree plantings gives much information on both large and small trees that are relatively free from diseases in Illinois.

This circular, for some time out of print, can again be obtained by writing to the Survey.

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OCTOBER 1964, NO. 24

Gay Travelers

Sometime this month you may see or may already have seen great clusters of beautiful large butterflies hanging in masses from trees along the edges of woods or literally thousands of them flying at low levels over roads and fields. These are the common beautifully colored monarch butterflies near the start of their annual southward migration. Hundreds of entomologists from all parts of the North American continent, including staff members of the Survey, have pooled observations for many years to gain an understanding of these remarkable and unusual migration patterns.

In summer we see these butterflies by ones or twos leisurely flitting haphazardly over the fields in the United States and southern Canada, with no hint that they are extensive travelers. During the summer they sip nectar from many common flowers, and at intervals the females deposit a few eggs on the underside of milkweed leaves. The eggs hatch into larvae that feed on the leaves, grow into large dark caterpillars, and pupate. In a few days a dainty new monarch butterfly emerges from the pupa or chrysalis.

The haphazard flight of these butterflies continues throughout the summer but a change in their daily habits occurs with the advent of cooler nights. As early as August in the northern part of their range and September in Illinois one may note that the direction of flight of many of the monarchs is in a south to southwesterly

Monarch butterflies showing darker pattern on upper side of wings and (right) brighter coloring visible on underside of wings.

direction. As autumn progresses, the numbers flying southward increase both numerically and percentage-wise. In Illinois peak numbers of these flights are usually reached in October.

These southward flying monarchs are migrating to the Gulf coast, Mexico, and the California coast to spend the winter as adults. On the journey south many of these butterflies congregate on particular trees to roost at night. Many thousands may occur in a single roost so that the tree appears as an orange mass with only a small amount of its green foliage exposed. The females occurring in these roosts are comprised of those that have never laid eggs, as evidenced by their underdeveloped ovaries. Also, those that occupy roosts have ample supplies of fat in their bodies; this appears not to be utilized as a source of energy on the journey. The females that have the developed ovaries are found to lay eggs on milkweeds as they move south and also to spend the nights singly on trees and weeds near fields.

In the northern parts of the over-wintering area, the adults are found to roost in masses as they did on the southward trip, but in the southern portions of the area they fly about and spend the nights singly. During February and March the northward journey is commenced. The monarchs exhibit some distinctive differences on this trip as compared to the fall migration. Instead of a leisurely flight interspersed with frequent feeding, the wingbeat and flight is rapid and direct and feeding is rare. The butterflies appear to subsist chiefly on the fat stored in their bodies all winter, and some females lay no eggs until they reach areas far to the north where the summer cycle of reproduction commences again.

Roadside Resource

The ring-necked pheasant, one of our most popular game birds, may suffer from current land-use trends in some sections of Illinois. Research by Survey biologists over the past ten years has shown that over 60 per cent of the pheasant chicks in Ford and McClean counties are produced in hayfields (legumes and grasses), small grain fields (oats and wheat), and pastures. In the past few years the land-use practices throughout the prime pheasant range of east-central Illinois have changed considerably, with a trend toward more row crops (corn and soybeans) and correspondingly less hay, pasture, and small grains. These changes could have substantial effects on the ability of pheasants to maintain their numbers in this area and provide the quality of hunting that now exists.

Since 1962, Survey biologists have tested the feasibility of establishing and maintaining hayfield-type cover for nesting pheasants along country secondary roads. Most of the existing roadsides are now covered with short grasses or weeds that generally make poor nesting cover for pheasants. In the spring of 1962, a total of 7 miles of roadside (15 acres) in Ford and McClean counties were plowed, disked, and seeded to a mixture of legumes and grasses. By the summer of 1963 the seedings were mature enough to provide pheasant nesting cover, and the experimental plantings and an equivalent acreage of unseeded (control) roadsides were searched for pheasant nests. Survey wildlife researcher G. B. Joselyn reports that the number of successful pheasant nests on the seeded roadsides exceeded the number on the control roadsides by 1.4 times in 1963 and 1.8 times in 1964.

These initial results give an exciting indication that here may be a way of increasing pheasant production substantially as agricultural practices reduce field-nesting potentials. But two problems have been encountered. First, some sort of weed control may be necessary before the roadside seedings will be acceptable to farmers, and second, establishing the seedings is moderately expensive. Wildlifer Joselyn is now trying to find answers to these problems.

Infiltration

Two new potential insect pests were discovered in Illinois this summer. On May 25, Survey entomologist Clarence E. White discovered a plant bug *Amblytylus nasutus* on bluegrass in Champaign

County. A European species introduced into North America over forty years ago, this grass feeder had spread from Massachusetts to Indiana and Michigan by 1940.

On August 26, Survey entomologists J. H. Bigger and R. E. Sechriest captured the first Illinois specimen of the western corn rootworm *Diabrotica virgifera* near Rock Island. Originally known as a rare native species in New Mexico, Arizona, and Colorado, when first known in the 1870's, this species has spread eastward year by year, especially in the wake of the use of irrigation and corn raising in Kansas, Nebraska, and South Dakota.

Both the plant bug and the western cornroot worm would seem to have moved westward and eastward, respectively, following genetic changes in the edge populations of the species, endowing them with greater adaptability for new climates and conditions. Dr. M. W. Sanderson, the Survey taxonomist who identifies these little insects, points to the lesson of these two species: that any now non-noxious plant-feeding insect in eastern or central North America has the potential to change genetically and become an agricultural pest.

Scientific Assistance Abroad

Aquatic biologist R. Weldon Larimore is back at the Survey after a challenging assignment in Thailand. There he was employed by the Food and Agriculture Organization of the United Nations to work with the Thai government, to apply know-how developed in Illinois to increasing the fish production of the inland waters of Thailand.

In Thailand the fresh-water fish are an extremely important part of the national economy, being the largest source of protein to supplement the staple diet of rice. The Thais prefer fresh-water fish to marine fish. The inland waters contain over 600 different species of fish compared to the 200 fishes found in Illinois. The thirty most important Thai fishes include the carp and many of its relatives, several catfishes (one attaining a size of half a ton), several perch-like species, eels, and the tilapias or mouthbreeders. They have no representatives of our North American bass and sunfishes. Fish for the table are caught from nearby waters by some member of the family or are obtained at a low price from a local fisherman.

Because of the great productivity of the hot, rich, tropical waters of Thailand, until recently there has been plenty of fish for the demands of the people. The recent rapid rise of Thai populations, however, has resulted in increasingly heavy fishing. In addition agriculture, industry, and urbanization have encroached on many flood plain areas that formerly produced huge quantities of fish. As a result of the increased human population and decreased area of fish production, the old hit-and-miss methods of fish culture and harvesting need to be replaced by management programs based on accurate scientific investigation and assessments.

When in 1962 the Thai department of fisheries requested technical assistance from FAO, the latter asked Dr. Larimore to take on the assignment. Obtaining a leave of absence from the Survey, Dr. Larimore left in July, 1963, and spent the next year in Thailand working with its Division of Inland Fisheries. This Division has a fine system of fisheries laboratories and a permanent Thai staff that has had some technical training but is inexperienced in the theoretical aspects of fish management.

Typical pheasant nest in hayfield. There are usually 10 to 12 eggs in each clutch.

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It was Dr. Larimore's duty to review the Division's program and facilities, assist in the planning and initiation of new fisheries projects, aid in the training of local workers, and re-examine and evaluate projects based on preliminary results at the end of his stay.

On the return trip to Urbana, Dr. Larimore visited several fisheries laboratories in western Europe, trying to discover why some introductions of American species into European waters had flourished and others had failed. He believes that his experiences in Thailand and Europe will give him additional perspectives for research leading to improved management of Illinois stream fisheries.

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NOVEMBER 1964 NO. 75

Bad Actor

This summer a farmer in Alexander County was extremely worried by one of his fields of corn. Many of the plants reached a height of 1 or 2 feet and died. Most plants did not grow more than 3 feet high and had at most small or medium sized ears. The leaves of many plants had a reddish tinge and streaks of white or yellow down the blades. The taller plants had very short upper nodes, giving the upper part of the plant a bunched appearance. Survey plant pathologist G. H. Boewe reports that these are the classical symptoms of corn stunt disease caused by a virus. First observed in the San Joaquin Valley, California, in 1942, this disease or strains much like it have since been reported from Central and South America, Mexico, Arizona, New Mexico, Texas, and in several southeastern states. In recent years a virus disease producing the same symptoms has been observed in scattered localities in Indiana and Ohio; this year it was found in southern Illinois.

How does this disease spread? The only known vector of the typical stunt disease is a little yellow leafhopper having two black spots on its head and measuring about 3/16 of an inch long, called *Dalbulus maidis*. The midwestern strain, on the other hand, appears to be transmitted by the corn leaf aphid, perhaps by other aphids, and by mechanical means. This difference in transmission behavior indicates that midwestern corn stunt is caused by a distinctive and possibly new disease-producing virus.

Although the yield of infested fields may be reduced 50 per cent or more, Survey entomologist G. C. Decker points out that

Corn severely affected by a corn stunt disease in Alexander County. The young man in the picture is 6'3". (Photo by G. H. Boewe.)

we do not know enough about this disease to assess its threat to corn production in the Midwest. Late this month Dr. Decker will participate in a corn stunt conference at Wooster, Ohio, called by the U.S. Department of Agriculture and the Ohio State Experiment Station. There entomologists and plant pathologists will compare notes and try to get a better idea of where we stand with this disease.

Say "Ah-h-h-h"

If we aren't feeling well, the doctor can poke us here and there, say "Does that hurt?", or "How does that feel?" and frequently get a good notion as to what is wrong with us and what caused the trouble. When his fish appear to be in poor health, Survey biochemist R. C. Hiltibran cannot elicit any such vocal response from his animals. Yet knowing what is wrong with them and what caused it is very important to Dr. Hiltibran. In the first place, he is trying to find out how fish respond to the various amounts and kinds of insecticides, herbicides, detergents, and many types of industrial wastes that find their way into the water systems of Illinois. Second, he is interested in finding chemicals that will kill undesirable waterweeds but will not harm the fish.

Because the fish can't talk, it has been necessary to find out by laborious experiments how the various vital tissues of fish are affected by different concentrations of the pollutant chemicals. To make things more difficult, virtually no work has been done on the inner workings of fish, hence it was necessary for Dr. Hiltibran to find out how the vital life processes of fish compared with those of man, rats, vinegar gnats, and other animals in which these activities have been worked out in detail.

Starting his investigations with different weed killers, Dr. Hiltibran found that many of them harm fish by interfering with the uptake of oxygen or with the transfer of energy from foodstuffs to certain phosphorus compounds. These compounds are the ultimate little "dynamos" providing the driving force within the cell for the many activities that keep an organism alive. These energy transfer activities are performed by extremely minute bodies called mitochondria, tiny organelles distributed within the living cell. This process of energy transfer and use involves a large number of extremely complicated steps. It has been found that different chemicals may block these processes at different points in the cycle or may actually uncouple some of the energy before it can be used by the cell. These matters were discussed in Dr. Hiltibran's paper "Oxidative Phosphorylation by Bluegill Liver Mitochondria," read at the Sixth International Congress of Biochemistry held recently in New York.

Many of the insecticides and herbicides (including those used to kill waterweeds) are large chemical molecules having two parts. Dr. Hiltibran is finding that in some of them one part of the molecule seems to be that which produces the lethal effect on the plant, whereas the other part of the molecule appears to control the toxicity of the compound to fish. He foresees the possibility of juggling these two parts to arrive ultimately at an herbicide that will combine extraordinary plant killing powers but have little or no toxicity to the fish. It is certain that helpful suggestions for fish management, pollution detection, and a knowledge of permissible pollution levels will become apparent as more is learned about this great unexplored field concerning the internal chemistry of fish.

Seeing the Unseen

What do wild animals do throughout the whole twenty-four hours of the day? How far do they wander? Where and when do they sleep? Do they always sleep in the same place? Are they solitary or social? These are questions that need to be answered to establish the potentials of these animals as carriers of diseases (both of themselves and also of humans), to know how large a population can be maintained on a given area, and to figure out ways of managing desirable species as game resources.

Until recently, much of our information on these questions was largely surmise. If stalked by observers, the habits of animals were unnatural, and the great bulk of

Fawn showing the small two-year radio transmitter attached around its neck. The test wire that looks like a rope is twisted off at the collar when the fawn is released. (Photo by W. D. Zehr.)

their activity at night was completely invisible to human eyes. With the development of miniature transmitting radios that could be attached to animals, and with signals from these sets picked up by direction-finding receivers, the path has been opened for our first real insight into many habits of wild animals acting naturally without human interference. This month the Survey is initiating its most ambitious project in this field. A complex automatic radio-tracking system, designed and constructed by wildlife specialist W. W. Cochran, will be used to determine the movements of fifty or more selected deer on the Dixon Springs Agricultural Center in Pope and Johnson counties.

Radio signals broadcast by small transmitters placed around the neck of each deer will be intercepted by two continuously rotating antennas placed on towers. The towers, one 55 feet high sitting on a bluff and the other 125 feet high are located about 3 miles apart. Information will be sent via radio telemetry from each of the towers to a central office, where the data will be recorded on 16 mm. movie film. Data, including time of day, date, direction from the receiving antennas to the deer, and the identity of the deer being tracked, will be read from the film and punched onto IBM data cards. An IBM 7090 computer located in Urbana will be programmed to compute the locations of each deer when the radio-fixes were made.

The tracking system is designed to provide a location on each radio-marked deer once each 1½ minutes, 24 hours per day, 365 days per year. Transmitters to be placed on deer are designed to operate for about two years before their batteries fail.

The detailed information on deer movements will be of especial interest to Survey wildlife researchers Glen C. Sanderson and G. G. Montgomery. They hope to find out how much of the living space available to them is used by the deer, and possibly why each individual selects a particular part of the available habitat and neglects another. Important is the possible role that learning and habit may play in the selection of home ranges. Deer are social animals, and members of each family group, exclusive of the father, travel together until the young are nearly one year old. The young thus have the opportunity to become familiar with the home ranges of their mothers and to acquire the habit of moving within them. This common movement of does and their young presents the possibility that deer tend to establish their home ranges within or near the home ranges of their mothers. Information gained by use of radio-tracking should tell us the strength and persistence of the influence of mother-young social relations on the selection of home range sites, the duration of their use, and the pattern of movements of the deer on their home ranges.

"Tomorrow's forecast is . . ."

If the weatherman thinks that he has troubles predicting tomorrow's sunshine or showers, he should try predicting insect outbreaks. Early in the year the entomologist is asked to gaze into his crystal ball and predict what insects will be bad on what crops during the entire coming year. This information is used by farmers and dealers in making tentative plans for sum-

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mer operations and for laying in stocks of insecticides.

So many variables of weather, parasites, and plant conditions contribute to insect abundance that anything can happen. Even so, certain types of prediction can be made with accuracy. If overwintering levels of chinch bugs or of grasshoppers are unusually high, one can predict that, the weather being favorable, next year's threat by these insects will be great. If the spring and summer weather should be unfavorable to these insects that were abundant in hibernation, the threat may disappear dramatically. There are so many different injurious insects, however, that any weather is unusually favorable to some of them, so that as one threat may disappear another set of pests may suddenly spring into prominence.

That is what happened last summer. Whereas many notorious pests like the hessian fly, the chinch bug, and the grasshopper did not reach anticipated or particularly harmful numbers, many species of pests belonging to the moth group reached unexpected, destructive levels. In over half of the state, Illinois farmers were confronted with perhaps the most extensive and damaging armyworm outbreak in two decades. This infestation progressed into the northern states and Canada where the infestations rivaled those of the famous outbreak of 1914. The caterpillars of other moths, including the corn earworm, a usually rare species called *Simyra henrici,* the sod webworm, the fall armyworm, the green clover worm, and the black cutworm were much more abundant than usual and caused extensive injury to crops.

Why these members of the moth group became unusually abundant we don't know. It may have been favorable weather, or a decrease in parasites. Survey entomologist J. P. Kramer points out that some of the protozoan parasites of certain of these moth larvae are at an unusually low ebb. His colleague H. B. Petty, who has followed insect pest abundance in the state during the entire year, reports also that insect parasites of corn borers are at a low ebb. Dr. Petty points out that the combination of high overwintering populations of corn borers and what appears to be a drastic decline in their parasites may mean that next year we could be faced with a tremendous upsurge in corn borer populations.

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DECEMBER 1964, NO. 26

Fox Findings

The red fox is a controversial figure in Illinois wildlife. Accused unjustly of reducing pheasant and quail populations, caught occasionally killing domestic fowl, valued at times for its pelt, thrill-giver to many hunters, it has both avowed enemies and staunch friends. In spite of the voluminous opinions about it, we still know very little about the red fox in Illinois, including its potential role as a reservoir of diseases of man and domestic animals.

When Survey wildlife specialists first devised radio-tracking techniques, the red fox seemed to be a marvelous test animal to find out how well the equipment would work under trying conditions. Wildlife specialist G. L. Storm fitted three adult and two juvenile red foxes with miniature collar-type transmitters, and was able to follow movements of two adults for ten months and one juvenile for nine months; the radios on the other two foxes lasted only a short time. Day and night radio fixes plotted on a detailed map of the test woodland near Savanna gave 24-hour clues concerning the movements of the animals.

The adult foxes rested by day, traveling almost continuously during late afternoon, night and early morning. During each travel period they reached a maximum of about a mile from their resting area, the largest recorded movement being a mile and a half. Each morning they came back to the same resting area, but did not bed down on the same exact spot on any two days. The total range occupied during the year by a breeding pair averaged about 1½ miles by 1 mile, or a section and a half per pair. When the pups were first born (late February or early March), the male kept a close association with them for about two months; this association decreased during the next three months and during late summer and early fall the male had almost no association with the family.

The juveniles moved to new dens from time to time. They stayed close to home for a few months, but by the time they were three months old they would move a quarter of a mile a day away from the den, and would increase the distance with age. By mid-winter the juveniles, now well-grown, moved to new ranges from six to twelve miles away from the parental range.

What You Can't See

Unlike the proverb, sometimes this does

Portrait of red fox cub. (Photo by W. E. Clark, former Survey photographer.)

hurt you. In Illinois communities conducting intensive spray and sanitation programs to control dutch elm disease, the disease has continued to spread to nearby healthy elm trees. When roots of two trees of the same species intertwine in the soil, some of the rootlets from one tree fuse with those of the other, forming a natural root graft. Plant sap and other materials can then flow through these unseen channels from tree to tree. It had been known for some time that the dutch elm disease fungus would spread to healthy trees through these root grafts and it was suspected that this type of transmission might be the principal cause of the poor showing of some of the control programs. To test this idea, Survey plant pathologist E. B. Himelick and Dan Neely studied the relationship of infection to the distances separating adjacent trees. Their calculations and tests indicate conclusively that when a majority of the elms in a community are growing within twenty-five feet of each other, or closer, approximately half of the new infections will be by root-graft transmission.

For several years this team has been testing various soil sterilants that would kill tree roots in the immediate area of application, with the idea of rendering the root grafts functionless. They found the most effective chemical to be Vapam, which will kill the roots within a foot or so of the point of injection. The compound literally cauterizes a short root area and stops normal flow of sap through the grafted roots. Last summer in Geneva and Barrington intensive tests of Vapam were conducted on seventy healthy trees adjacent to trees with early wilt symptoms. Holes ¾ inch in diameter and 15 inches deep were drilled six inches apart in a line between the two trees, and Vapam solution was put into the holes, which were then closed with the heel to prevent gas dissipation. In practice it was found that sidewalks, hedges and other obstructions made it impossible to achieve an unbroken straight line of holes between the two trees, and various attempts were made to compensate for this.

Recently tabulated results of this first large-scale test show that the treatment saved two-thirds of the trees. Dr. Himelick points out that their inability to cope with obstructions such as driveways and sidewalks evidently accounted for some of the cases of failure. It is possible that special tools for applying Vapam underneath such obstructions might overcome this difficulty. Dr. Neely adds that other failures may have been instances in which the trees had already become inoculated with the disease fungus through the root grafts before the Vapam treatment was applied. Treating the root grafts of neighboring trees must therefore be done at the earliest possible time after trees become diseased. Means of spotting diseased trees immediately after they are infected is thus of primary importance in control of the disease through soil sterilants.

Information and recommendation on the use of these soil sterilants can be obtained from the Survey.

Under Your Feet

When you walk over the prairies or through the woods, do you ever realize that you are treading on the "roof" of one of the most populous parts of the world? The leaf mold that lies next to the earth furnishes food and shelter for millions of individuals and hundreds of different kinds of living things that complete their entire lives there — mites, millipedes, beetles, flies, thrips, pseudoscorpions, spiders, and many rare types. A large number of these animals feed on the fungi living on the decayed material, others feed on the decaying material itself. Other inhabitants, such as centipedes and certain insect and mite groups, are predators or parasites that feed on their animal neighbors.

In winter this leaf-mold microcosm is swelled by large numbers of hibernating animals. Many leafhoppers, parasitic wasps, lacewing flies, and bugs that spend the summer in grass or woodland niches above the leaf mold, descend at the turn of winter into the shelter afforded by the dead vegetation pressed to the earth. Some of our agricultural pests overwinter in

Dr. Stannard putting leaf mold from sack onto one of the Survey's battery of twenty-four steam-heated collecting funnels. (Photo by Survey photographer Wilmer Zehr.)

this fashion, including chinch bugs and box elder bugs.

Different types of vegetation — grassland, marsh, swamp, shrubland, or forest — have leaf mold supporting entirely different species or kinds of these animals. Many of these leaf-mold species are so tiny or elusive, however, that the collector would seldom find them by even the most tedious and time-consuming sifting through the leaf mold.

To survey and assess this important element of Illinois life, Survey entomologist L. J. Stannard must use special techniques. Entomologists usually use cloth nets to catch insects. Dr. Stannard uses a tin net, called a collecting funnel. These funnels have a wire screen fitted across the opening about three inches below the wide end; they are suspended on a ring of brass tubing, and a bottle of alcohol is fitted against the narrow end. Leaf mold is carefully laid on the screen, a piece of tight insect-proof cloth is tied over the top, and steam or hot water is run through the coil on which the funnel rests. As the leaf mold heats and dries, the animals in it eventually fall down the funnel and into the bottle of alcohol which preserves them. The most minute organisms can be collected in this way. The process extracts practically every living animal from the sample, hence is ideal for sampling hibernating pests such as chinch bugs, and for obtaining accurate quantitative comparisons between leaf-mold inhabitants of different types of vegetation.

Dissolved "Life"

Fish in the water need just as much oxygen to stay alive as do humans breathing free air. Fish swallow water and run it out through their gills; these gills contain intricate and delicate membranes that can absorb into the blood the life-giving oxygen dissolved in the water. Sewage, dead organic material such as kitchen wastes, and many by-products of industry and commerce contain bacteria and certain chemical compounds that use great quantities of oxygen. The bacteria and chemicals are unusually efficient in extracting dissolved oxygen from water; if present in sufficient quantity they will reduce the oxygen supply below the level necessary to keep fish alive.

Because of its tremendous potential as a resource for fisheries, Survey aquatic biologists have been studying the Illinois River for over half a century. Up to about 1910 this river was one of the most productive commercial fishing streams in the world, but thereafter, pollution from Chicago and the growing cities along the river eliminated commercial fishing downstream almost to Havana. Installation of

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sewage treatment plants and other safeguards began improving conditions, but the fisheries' catch is still only 15 per cent of that of the early 1900's.

Survey aquatic biologist Dr. W. C. Starrett and his Illinois River crew make periodic checks of the river oxygen supply from Joliet to Hardin, 259 river miles. Dr. Starrett points out that the amount of dissolved oxygen in the river is controlled by many factors. Each of the Illinois River's seven dams acts like a waterfall and helps to re-aerate the water. In addition, the microscopic green plants in the water produce oxygen by photosynthesis during the hours of sunlight. On the other side of the ledger, when water is warm it does not dissolve oxygen so readily, and at night the microscopic plants that produce oxygen during the day need to use some of the oxygen to keep alive. Knowing this, Dr. Starrett takes his oxygen samples during the early morning hours of the warm months — the most critical time for the fish, as oxygen is in its lowest supply.

Fishes differ in their oxygen requirements. Goldfish, bullheads, and carp can withstand lower oxygen conditions than can channel catfish and sheepsheads. Buffalo and bass need even more oxygen than these. In some parts of the river, goldfish, carp, and bullheads are the only species of fish present.

Dr. Starrett found this year that oxygen conditions in the Illinois River are still grim. Parts of the river support only a few photosynthetic organisms and the bacteria and chemicals in the river make great demands upon its oxygen.

In a healthy stream in Illinois the oxygen ranges from 7 to 12 p.p.m. (parts per million), but should never go more than a few decimal points below 5 p.p.m. In summer, oxygen in sections of the Illinois River goes down to 2 to 2.5 p.p.m. The navigation dams have a beneficial effect but these are soon offset by action of organic pollutants. Except for a stretch a few miles below each dam and part of Peoria Lake and the Alton navigation pool, the dissolved oxygen was below 4 p.p.m. These figures mean that conditions in the Illinois River will have to be greatly improved before its present low productivity of commercial and game fish will increase.

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JANUARY 1965, NO. 27

Waterfowl Passage

Although Illinois hunters scanned the sky hopefully for flights of ducks, the 1964 season was well along before many dotted the daytime sky. This was not because there were no duck flights; these came with every cold front. But in October and early November these fronts were weak, and the ducks were under no compulsion to move great distances. They were content to make short hops, and flew only at night.

Beginning November 16 hurrying flocks of south-bound ducks made hunters anxious to be afield. The storm of November 20 brought the last big duck movement of the season but froze most waterfowl marshes, thus ending the season prematurely.

Mallards taking off from an Illinois marsh. (Photo by former Survey photographer William E. Clark.)

The highlight feature of the 1964 season was the switch of many ducks from the Illinois to the Mississippi Valley. In 1955 the Illinois Valley attracted two-thirds of the ducks, while only one-third appeared in the Mississippi Valley. This year, as during the last two, ducks have been about equal in numbers in the two valleys.

Survey wildlife specialist Frank Bellrose points out that this changed pattern of duck abundance stems from recent changes in waterfowl habitat. In the Illinois River and its lakes, soil pollution has almost completely eliminated the aquatic plants that ducks eat most often. Domestic pollution has nearly eliminated the snails and "fingernail clams" that provided the basic food for bluebills, canvasbacks, ring-necked, and ruddy ducks in the Illinois Valley. Corn combines and increased fall plowing have reduced the amount of waste corn and stubble available for mallards.

As these duck food resources decreased, duck clubs of the middle Illinois valley began to "dewater" sloughs, ponds, and lakes in summer to increase the growth of moist soil duck food plants such as millets, smartweeds, and nutgrasses. Because of these food supplies, ducks were over twice as abundant in the middle than in the upper Illinois Valley.

While waterfowl habitat has deteriorated along the Illinois River, it has improved along the Mississippi. There new waterfowl refuges have been created and

the food resources of old refuges enhanced. Several years of reduced flow during the summer have greatly increased aquatic duck food plants in pools behind the navigation dams. Duck numbers have adjusted to these changes in food supply.

Total duck populations appear to be on the rebound. In this decade the Illinois peak was 2,450,000 ducks in 1955, the low, 933,000, was in 1961. By 1963 duck numbers had risen to 1,428,000, and this fall they rose further to 1,620,000.

Flying Conference

To acquaint vitally interested people with progress in the extensive wildlife–pesticide research being conducted by leading laboratories across the U.S., the National Academy of Sciences asked H. B. Mills, Chief of the Natural History Survey, to organize and conduct a Travelling Pesticides Symposium that would spend a week visiting research installations from the Atlantic to the Pacific. Thanks to financial backing by the Massachusetts Audubon Society and the Manufacturing Chemist's Association, a DC–6 was chartered and a tight itinerary was organized for the symposium.

Participants represented conservation agencies such as the National, Massachusetts, and Michigan Audubon Societies; National Wildlife Federation, Izaak Walton League, and Sport Fishing Institute; private professional groups such as the American Medical Association and the Entomological, Ecological, and Wildlife Societies; and federal executive agencies such as the President's Science Advisory Board and the President's Consumer Interest Committee. Representatives of the Health, Education, and Welfare, Interior, and Agriculture Departments; of chemical manufacturing companies; and a Congressman also took part.

From November 15 to 21 the group inspected current research at the U.S.D.A. laboratories at Beltsville, Maryland; American Cyanamid's research laboratories at Princeton, New Jersey; the HEW's Taft Laboratory in Cincinnati, Ohio; the Bureau of Sport Fisheries and Wildlife's installations at Denver, Colorado; and various agencies of the State of California at Davis. This put the participants in personal contact with specialists throughout the country and allowed unimpeded discussion among the participants, with informal debate of diverging views. To guarantee the greatest freedom of restraint, this symposium received no publicity either before or during the trip; it kept no minutes, and it contemplated no final report.

Dr. Mills reports that participants overwhelmingly endorsed the trip, and were amazed at the extent and scope of current research centered around the wildlife–pesticide problem. They valued "the opportunity to get an appreciation of the other fellows' point of view," "an interchange of thoughts among persons with diverse interests and prejudices," "a more intergrated viewpoint," and "the opportunity to broaden our understanding of a complex problem." As one participant put it, "This symposium may not have changed many minds but it certainly did open many!"

The most important feature of this trip was that it was made, that persons of divergent interests wanted to get an understanding of as many pros and cons as possible on an important issue. This is a necessary step toward achieving objective solutions to problems that will arise constantly in the growing complexity of human relations.

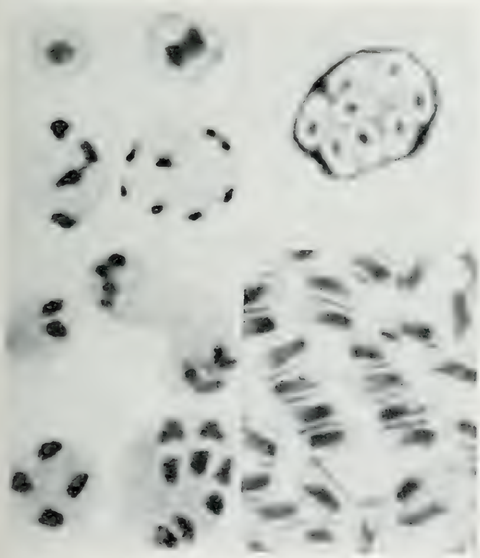
Friends Against Foe

Some people collect stamps or butterflies or Etruscan bronze ware, but the Survey's insect pathologist John P. Kramer collects dead or dying insects. The real objects of his search are microscopic one-celled animals or protozoans that parasitize and kill the insect. Last summer his assistant J. V. Maddox brought Dr. Kramer a most unhealthy armyworm larva; in its fatbody Dr. Kramer found two kinds of his little pets belonging to the protozoan group called microsporidians. In follow-up cultures, these two species multiplied amazingly well. Additional field collections showed that both species always occurred to-

gether in the same insect larva. Pilot studies in the laboratory showed further that several economic species of caterpillars are susceptible to attack by these two species of minute organisms.

When a caterpillar dies because of these parasites, it eventually disintegrates and the spores of the parasite contaminate the leaf surface of the host plants. When these contaminated leaves are eaten by another caterpillar, the spores germinate in its stomach, work their way through the stomach wall into the body cavity of the larva, and take up residence in the fatbody, which is an extensive tissue throughout the larva. The growing stages of the microsporidians multiply at a great rate and, when most of their food is exhausted, change into a resistant spore stage that escapes from the larva after the latter dies and disintegrates.

The two microsporidians isolated from the armyworm larva proved to be new kinds or species never before discovered and so far known only from Illinois. Their initial effects on laboratory hosts were so dramatic that Dr. Kramer and Dr. W. H. Luckmann, his entomological confrere, set up initial tests using the parasites against corn earworm larvae, a major pest of many field and vegetable crops. Again the results were remarkably encouraging — the corn earworm larvae literally withered away after being infected. Especially interesting is the circumstance that, in spite of the tremendous effect these parasites have on insects, they are completely harmless to other kinds of life.



The two internal microsporidian parasites of corn earworm larvae; four growing stages on the left, infectious spore stage on the right. Above is the species *Thelohania diazoma*, below is *Nosema necatrix*. Magnified about 2,000 times. (Photo by Survey photographer Wilmer Zehr.)

The next question is — will these parasites perform as well in field applications, under extremes of the Illinois climate, as they have in the experiments conducted in the greenhouse? This is a problem these two scientists will tackle. Dr. Kramer points out that we need to know how many parasite spores each larva must eat for the infection to produce lethal results, and how long the spores will live and remain infective outside the host insect. Dr. Luckmann adds that we will need to develop practical means of growing the parasites in large numbers so that we can apply the spores in areas where needed for actual pest control. The results of these lengthy and extensive tests will tell us whether or not we have another useful biological weapon in man's arsenal against noxious insects.

Chlorotic Dwarf of White Pine

Illinois Christmas-tree growers have been concerned about a disease known as chlorotic drawf of white pine in their white pine stands. It produces thin, weak twigs and extremely short, yellow needles, some of which die back at the tips. Affected trees grow at most a few inches in height each year instead of the normal 1 to 3 feet. The trees continue in this condition for a number of years, then usually die. Losses run from 5 to 20 per cent. In timber stands this loss may be minor because as the trees grow older, adjacent trees may compensate by greater growth. In Christmas-tree plantings, however, plants are harvested before adjacent trees are big enough to make such compensation and the financial loss is serious.

Plant pathologists first looked for bac-

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teria or fungi as the cause of this dwarfing, but extensive tests failed to disclose either of these plant disease organisms. The general symptoms suggested a virus as the cause. To test this, Survey plant pathologist Walter Hartstirn located adjacent disease and healthy trees, then grafted branches of a diseased tree to those of a healthy tree so that fluids of one tree could pass readily into the tissues of the other. Dr. Hartstirn was concerned that deer running through the plantation would break the grafted unions, so he set up string and stake baffles to protect them. Mice stole the string and used it for their nests but the deer didn't harm any of the grafts.

In no instance did the disease spread from an affected to a healthy tree, indicating conclusively that no virus is involved. Dr. Hartstirn noted quite the opposite: many diseased trees grafted to the healthy trees became well. If the graft was broken after such recovery the disease condition reappeared. This indicates that the cause of the disease is some sort of chemical deficiency (that may act like the enzyme insulin in diabetes) of a necessary substance that the diseased trees were obtaining from the healthy trees. The frequency and early stage of appearance indicate that the physiological deficiency is almost certainly under genetic control.

These studies add chlorotic dwarf of white pine to the ever-growing list of "physiological diseases" affecting plants. To understand these we need to know a great deal about the genetics or inheritance patterns of trees. Few institutions in the world have the long-term facilities and programs to investigate this avenue of research because of the many years often needed to produce seeds by the trees sown as seeds. Our increasing need to investigate these phenomena, however, may soon make it essential to initiate such programs.

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FEBRUARY 1965, NO. 28

Stock Taking

Now that another growing season has gone by, what has happened to the four major field crop insects recently found in or near Illinois? An intensive search by the cooperating Natural History Survey and University of Illinois extension entomologists, brought the following appraisal:

Alfalfa weevil. It is now widespread in twenty-nine southeastern counties roughly south of a line from Marshall to Vandalia, and east of a line from Vandalia to Murphysboro. Infestations are light. In other states it has usually taken three years for the weevil to build up to economic population levels, hence Illinois still has one year of grace. We are hoping that some of our parasites will take hold. Both larvae and adults of the weevil feed on alfalfa foliage. The larvae, which appear only early in the season, do most of the damage and may ruin the first cutting of alfalfa, while subsequent cuttings are seldom badly damaged.

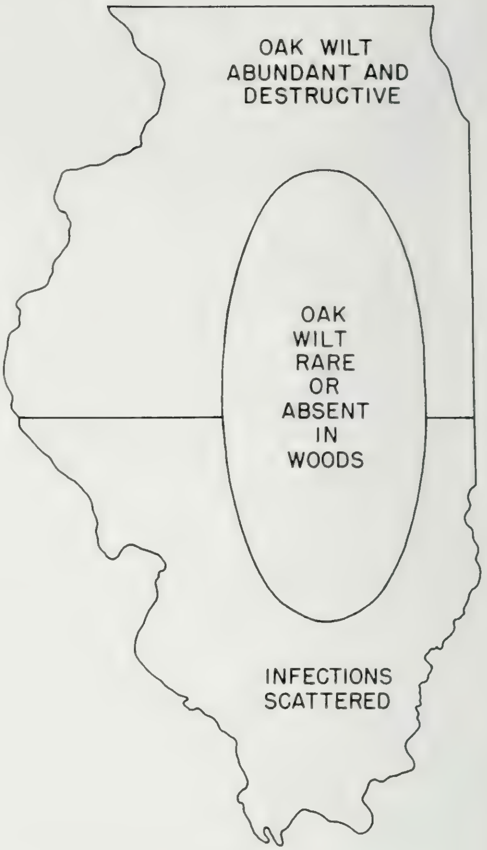
Southwestern corn borer. This is now known in Illinois' six southernmost counties where less than one per cent of the stalks were found to be infested. The only exception was one field of late corn in Alexander County that had a ten per cent stalk infestation. Entomologist C. E. White, responsible for much of this cooperative surveying, reports that only about two per cent of the borers overwinter this

Southwestern corn borer. *Left,* corn stalk blown over after being completely girdled near the base by the larva feeding from the inside. The remarkably clean break is a sure symptom of the work of this moth caterpillar. *Right,* the caterpillar, which grows to nearly an inch in length, feeding in the lower part of the stalk and crown, where it may hibernate. (Photos by H. B. Petty and C. E. White.)

far north, hence the chances are good that for at least some years the borer won't be a serious pest except locally and in late corn. If it gets abundant, however, it is devastating. The larvae girdle the stalk about 4 inches or less above the soil line, eating all the way around the stem from the inside. Thus, with only a thin outer shell to hold up the stalk, the first breeze snaps it off easily, especially if it is carrying a heavy ear.

Western corn rootworm. No more Illinois occurrences have been found since the capture of a single specimen in Rock Island County in August. The larvae live on or in corn roots and, when abundant, have the potential of practically destroying the stand. The adults may feed on the silks but seldom produce serious damage. This pest is a midsummer problem.

Cereal leaf beetle. Despite intensive search by entomologists of the Natural History Survey, Illinois State Department of Agriculture, and the U.S.D.A. have found no records of this destructive beetle in Illinois. It is abundant in Indiana not far from the state line where it is a serious early season problem primarily on oats and wheat. The first east winds blowing when the beetles are in flight probably will pepper east-central Illinois with the beetles.



General areas of oak wilt abundance in Illinois.

Rabbits

The cottontail rabbit, Illinois' number one game animal, is again due for a reappraisal, this time from the standpoint of increased recreational possibilities. One of the ideals of hunting philosophy is that the game be harvested as an animal crop shortly after the breeding season while game populations are at peak levels. Harvesting at this time of year will produce the maximum amount of hunting, yet leave enough animals to insure adequate breeding stock for the following year.

The rabbit season is now set considerably later than this ideal population point. The late season (now opening in late November) was so adjusted to reduce the likelihood of hunters contracting tularemia, which hazard is greatly reduced after several autumn frosts. Because the new "magic drugs," chiefly antibiotics, have greatly reduced the danger inherent in tularemia, the question now is, how much hunting is lost because of the late season?

James Bailey, biologist for the Department of Conservation and the Natural History Survey, set out to answer this question by studying the natural mortality of cottontail populations in that part of the year preceding late November. He found that largest populations of cottontails occur during midsummer. After early September, breeding decreases and the cottontails sustain a steady mortality due to predation and other natural causes. Their numbers therefore show a steady decline until the next breeding season the following year. Biologist Bailey found that this population decline amounted to 25 per cent in the six weeks preceding the opening of the hunting season and 40 per cent between September 1 and the opening of the season.

As Survey wildlife specialist Glen Sanderson points out, two questions now arise. First, did the later opening date for rabbit hunting result in a significant decrease in the number of human tularemia cases in Illinois? Second, has the medical problem of tularemia become sufficiently reduced that Illinoisans could enjoy an additional ten or twelve weeks of rabbit hunting every year; not only additional weeks but weeks during which the cottontails would be far more abundant than they are during the existing hunting season? Both questions are being investigated.

Oak Wilt

Foresters of the Midwest have had grave concern about oak wilt since 1944, when it was discovered to be caused by a fungus disease. Illinois forestry interests in particular have been worried since about 1950 when the disease was occurring in outbreak proportions in northern Illinois and neighboring localities in Wisconsin and Iowa, and in areas killed up to 50 per cent of the merchantable oak timber. Since that time Survey plant pathologist E. B. Himelick has been studying the disease in cooperation with the Department of Forestry, University of Illinois.

The fungus disease, technically called *Ceratocystis fagacearum,* kills trees of the red oak group within a year; it usually kills members of the white oak group branch by branch and normally takes several years to kill the whole tree. How the disease spreads from one locality to another is still not well understood. Certain fungus beetles, especially those attracted to the sweet-smelling, exposed fruiting bodies of the fungus, are known vectors. These carry spores on their bodies and introduce them into wounds in healthy trees. Once established in a locality, the oak wilt disease spreads through root grafts and produces an ever-widening circle of diseased trees.

Since 1952, Dr. Himelick has been testing different means of halting or curing the disease. In large timbered areas, the only effective control so far discovered is to kill wilting trees plus other healthy-appearing trees around them for a diameter of 30 feet, using an herbicide preparation such as 2,4,5-T. This is poured into circular cuts girdling the base of the tree so that the poison is transported through the conducting tissues of the tree. If new disease centers are treated promptly, this cuts down the chances of overland transport of the fungus by insects, and prevents the spread of the disease through root grafts from affected trees to surrounding untreated healthy ones. Treated trees having merchantable logs can be harvested for lumber. In landscape plantings or in areas where the trees are of aesthetic value, the use of soil sterilants or trenching will stop the spread of the disease organism through root grafts.

Dr. Himelick points out that a preliminary to control is spotting new infection areas, and to accomplish this he has been making aerial surveys of oak wilt throughout Illinois. In 1964 he completed the last segment, northern Illinois, the chief area where the wilt is of economic importance. This 1964 survey will give owners of lumber tracts and supervisors of state parks information as to where new danger points exist and the opportunity to initiate control measures. Information and detailed directions on the control of oak wilt disease may be obtained from the Survey.

How Many Fish?

In fish management, the total number of fish in a pond is currently calculated by the following steps. First a carefully counted number of fish are caught, marked, and returned to the pond. After a waiting period, allowing marked and unmarked fish to mix, subsequent seine hauls of fish are made, the number of marked and unmarked fish are counted, and the pond population calculated from these figures. Let us suppose that the pond contained 100 marked fish, and a later sample of 50 fish included 20 marked ones. The marked ones are $20/100 = 1/5$ of the marked fish in the pond, so that theoretically the total number of the catch (50) represents $1/5$ of the population, which would be $5 \times 50 = 250$. If the number of marked fish were higher, the calculated population would be lower. For example,

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if the sample of 50 included 25 marked fish, the marked ones would be 25/100 or ¼ of the total marked fish in the pond, hence, theoretically, the sample should be ¼ of the total population, which would be $4 \times 50 = 200$.

The use of this formula is based on the assumption that the marked fish swim around in random fashion, become evenly mixed among the entire population, and are recaught at random.

During some of their pond studies, Survey fisheries biologists D. H. Buck and C. F. Thoits became suspicious that something was wrong with their pond population estimates based on this method. To test this situation, they made series of extremely careful seine hauls and applied the formula to their data to obtain theoretical estimates of fish numbers in each pond. They then drained the ponds and obtained an exact count of the fish they had been sampling.

When comparisons were made between theoretical sample estimates and the actual numbers of fish in the ponds, some peculiar discrepencies appeared. Estimates that seemed statistically to be reliable to 5 per cent were off as much as 50 per cent. Among bluegills, the estimates for older fish were found to be almost exact; for younger fish the population had been uniformly underestimated by about 50 per cent. This clearly indicated a difference in behavior between the two age groups. The older ones really were being recaptured at random, but the younger fish behaved in such a way that a greater proportion of marked fish than unmarked fish was being recaptured.

Figures for the yellow perch went in the opposite direction. Most of the seine estimations gave population figures that were too high, indicating that too few marked, individuals were being recaptured. Obviously the perch, once seined or marked had a tendency to avoid recapture.

At least for the species studied in these experiments, seining thus proves to be unreliable as a means of obtaining accurate population estimates in small ponds. Dr. Buck and his associate are now testing other sampling techniques such as electrical shocking as a means of obtaining accurate counts of fishes without resorting to draining the pond.

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MARCH 1965, NO. 29

". . . big as eagles!"

Already this year you may have swatted at the first pestiferous mosquito of spring, a grim reminder of the swarms that will soon emerge. Most people think of mosquitoes as being just one kind of insect, but actually there are over 3,500 different kinds or species in the world of which only 55 species have so far been found in Illinois. Some kinds are vicious biters that apparently carry no disease, organisms, some are painless biters that do carry disease organisms, and still others don't bite humans or animals at all.

The gallinipper, Illinois' largest mosquito, a vicious biter about half an inch long. (Drawing by former Survey entomologist C. O. Mohr.)

In each of these categories, the young aquatic stages or wrigglers grow only in temporary ponds, others in permanent marshes or swamps, others in tree holes containing water, and a few in tin cans, old tires, fish ponds, or pools of putrid water in town. Because of this diversity in feeding habits, disease relationships, and larval breeding places, it is extremely important to mosquito operators, sanitarians, and public health workers to know exactly which kinds of mosquitoes they are dealing with.

For many years the Survey's *Mosquitoes of Illinois* provided a means of identification for our mosquito species. To replace this report, now out of print, Survey entomologist H. H. Ross and University of Illinois entomologist W. R. Horsfall worked together to produce a revised *Synopsis of the Mosquitoes of Illinois* that will soon be available. This *Synopsis*, containing chiefly identification keys, has three new features:

- The keys have been enlarged to include not only three additional species taken recently in Illinois but also seven additional species that may eventually be found here.
- Keys to mosquito eggs have been added. Mosquito egg identification has opened up a completely new dimension of mosquito control.
- All users of the *Synopsis* who are not mosquito specialists will give a vote of thanks to Survey technical editor James S. Ayars. He has gone through the keys with a fine-tooth comb, substituting in every possible spot everyday words for technical terms, such as "hair" or "bristle" for "macrochaeta." The keys are not easy

(the mosquitoes see to that), but far less difficult.

Gladiolus Lovers

You may already be thinking of planting corms of your early varieties of gladioli, saving the later varieties to be set out in another month or so. Survey plant pathologist J. L. Forsberg warns that glad corms are frequently harmed or destroyed by various rots. To protect against their attack the corms should be soaked in a fungicide preparation before planting; then an insecticide and another fungicide should be applied in the furrows as the corms are planted. Every year Dr. Forsberg tests a wide variety of fungicides and insecticides with different varieties of glads, and recently has presented his 1964 summary at the annual meeting of the Kankakee County Gladiolus Growers' Association. This organization represents Illinois' thousand-acre, highly concentrated gladiolus industry. Dr. Forsberg pointed out that most past remedies are still effective, but one old friend, the fungicide Emmi, after giving good results for twelve years, became troublesome by delaying or preventing emergence of some plants and delaying blooming dates of others. Its replacement compound Memmi has so far given good protection without these adverse effects on the plants. Detailed information on the selection and use of fungicides and insecticides for gladiolus protection can be obtained by writing to the Survey.

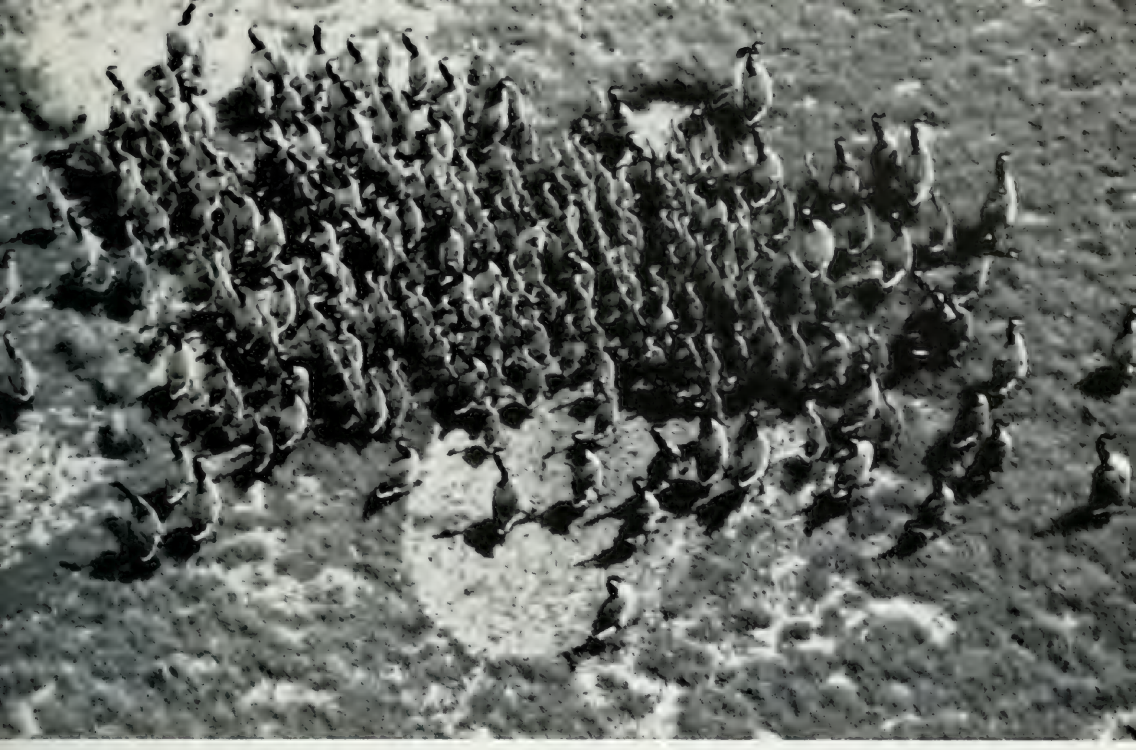
Honkers

As with the ducks, Canada geese numbers also went up last fall. Survey wildlife specialist H. C. Hanson, working with biologists of the U. S. Fish and Wildlife Service and the Illinois Department of Conservation, has just finished tabulating the Illinois goose picture for the 1964–1965 wintering season. In the spring of 1963 about 211,000 geese left for the north and about 218,000 came back that fall, representing an increase of only 3.4 per cent. In the spring of 1964 only 188,000 birds went north but about 271,000 came back last fall, an increase of 44 per cent. Dr. Hanson pointed out that only about 20 per cent of the females nested successfully in the northland during the summer of 1963, whereas close to 40 per cent were successful in bringing off a brood in the summer of 1964. Average 1964 brood size was also about 30 per cent higher than in the previous five years. The figures on nesting percentages were obtained by Dr. Hanson in his aerial surveys of Canadian tundra in cooperation with Ontario authorities. Dr. Hanson points out that these differences in population size and breeding percentages are brought about not only by yearly differences in weather, food availability, and predation, but are influenced more than we had ever thought by differences in goose behavior, especially differences correlated with population density. Dr. Hanson feels that in the long run these behavioral patterns may be the most important clues to predicting future population size in Canada geese, and is now making plans to intensify his studies in this area.

For Farmer, Gardener, and Milady

This year if you are troubled with insects on the corn, wheat, cabbage, cows, or chickens, or if the lady of the house is disturbed by ants, hornets, or fleas, you can get helpful information by writing to the Illinois Natural History Survey or the University of Illinois, College of Agriculture. Dr. H. B. Petty, University and Survey Extension Entomologist, aided by his entomological colleagues, has just released the *1965 Condensed Insecticide Recommendations* prepared annually through the cooperative efforts of the Survey and the University's Agriculture Extension Service. The four circulars give the best-known control for practically every Illinois pest insect except termites, for which special separate publications are available.

Three of the circulars include the same group of pests covered last year, one for vegetable crops, another for field crops, and a third of insects on livestock. This year Dr. Petty has added a fourth, *Insect Control by the Homeowner.* This will give



Flocks of Canada goose families on Akimiski Island, James Bay, July 11, 1964. Normally scattered over the salt marsh feeding area, the geese have bunched together at the alarm caused by the airplane. Note that, like the musk ox, the young birds are in the center of the ring, while the parents have established a defensive ring around the outside. (Photo by Dr. Hanson from an airplane at a 200-foot elevation, 100 miles per hour, with a telephoto lens at 1/1000 second.)

insect control recommendations for tree and shrub insects, vegetable, flower, and lawn insects, and nuisance species around the house, such as fleas, flies, and wasps.

Greatest changes over last year are recommendations for insect control of field crops. Certain chlorinated hydrocarbon insecticides are secreted in the butterfat when dairy cattle are exposed to even minute amounts of them; the legal tolerance for insecticides in milk is zero. Therefore the Illinois dairy farmer is urged to control insects with insecticides which are not secreted in the milk even if eaten in moderate amounts by dairy cows.

This step is not needed to protect public health nor to satisfy legal requirements, both of which are currently being met by Illinois dairymen. However, during the past two years, accidents, excessive drift, or misuse of chlorinated hydrocarbon insecticides in other states have led to voluntary dumping of milk followed by unwarranted and unfavorable publicity for the entire dairy industry. These accidents and unfavorable publicity can be avoided by adopting a policy that will enable Illinois dairymen to continue to produce a wholesome, nutritious and legal product.

Lake Chautauqua

Before 1900 the Illinois River had many large floodplain lakes that produced remarkable crops of fish. Early in the century many of these were levied off, pumped out, and used for farm land. Later many of the drainage districts dissolved and some of the lakes were re-established, especially by hunting groups. Lake Chautauqua is one of these floodplain lakes of about 3,500 acres, located near Havana, and is managed by the U. S. Fish and Wildlife Service as a refuge for migratory waterfowl.

Interest in the possible re-establishment of more of these old lakes for flood control raised the question as to how much commercial and sport fishing these re-established lakes could provide. To find out, the Survey and the Illinois Department of Conservation initiated a ten-year study of managed fisheries on Chautauqua Lake.

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News releases and "fishing schools" greatly increased the number of anglers; on most years 10,000 to 14,000 fished the lake. Commercial fishermen were given permission to use roundup sets of wing nets (a sort of corraling technique especially effective at low water levels in driving fish into large netted enclosures) and drag seines (especially effective in increasing the catch of shad, drum, and catfish). The commercial fishermen kept chiefly buffalofishes, channel catfish, carp, drum, and gizzard shad. They returned to the lake the sports-fishing species — crappies, bluegills, and bass.

During this intensive ten years of fishing, the average yearly commercial catch increased from about 30 pounds per acre to about 100 pounds per acre; the take of sports fish increased in about the same proportion. To find out the effects of this program on fish growth, changes in fish species, and changes in yearly broods, Survey aquatic biologist W. C. Starrett and his colleague A. W. Fritz weighed and measured 65,000 fish. From thousands of these, scales and spines were prepared for microscopic study to obtain age data.

Dr. Starrett reports that the increased commercial fishing had no perceptible effect on the sports fishing. It was thought that the heavy fish catch might increase growth rates, but they remained about the same as elsewhere. This apparently was due to the influence of fish coming from the river at high water and the extremely good conditions for reproduction and growth of small fish (which were not caught in the large-mesh commercial nets). The lake acted as a natural "nursery pond" for some species such as the white bass, that moved from the lake to the river when they were over a year old. Other fish moved little. Populations of commercial size fish in the lake fluctuated greatly from year to year. This appears to be correlated with years of heavy spawn, and this in turn seems to be correlated with different levels of the lake in wet and dry years. These and other results of this basic study will soon be available in the Survey's new bulletin by Starrett and Fritz, *A Biological Investigation of the Fishes of Lake Chautauqua, Illinois.*

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APRIL 1965, NO. 30

"Common Cold" of Sycamore

One of the most unsightly tree diseases is sycamore anthracnose, caused by a fungus disease that attacks leaves, twigs, and trunks of sycamore. It is primarily an early season disease which may blight the opening buds or leaves and which becomes established in the young twigs and branches, where it may produce unsightly cankers. Frequently it strikes when the leaves are out just an inch or two, and may completely defoliate the entire tree. Leaves will come out again later in the summer, but repeated attacks of the disease weaken the tree and it is more susceptible to attack from insects and winter injury.

Some years sycamore anthracnose is extremely severe. At other times its attack is almost negligible. In attempting to get some sense out of their accumulated records, Survey plant pathologists Dan Neely and E. B. Himelick made an intensive survey of disease severity over the Midwest and especially Illinois, taking their samples near weather stations. They discovered that this is a cold weather disease. After the sycamore leaves start to bud out, if the mean daily temperature ranges from 50 to 55 degrees, disease manifestations will be severe; with mean daily temperatures from 55 to 60 degrees, they will be moderate; and if the mean daily temperature is above 60 degrees few or no disease symptoms will appear.

In the next few weeks if the weather is cold and clammy, you will be making sure that your child puts on his coat before dashing outdoors. This is a sure sign that you should give a thought to your sycamore trees. If the temperatures and temperature forecasts are in the danger ranges, Dr. Neely points out that a number of fungicidal sprays will give excellent protection to sycamores against the anthracnose disease organisms. Details and techniques for sycamore protection are available from the Survey.

Fishy Factor X

Fisheries biologists over the nation have advocated more procedures for fertilizing and managing fish ponds to get increased fish production than there are recipes for making hot biscuits. Numerous small-pond experiments designed to compare and test many of these procedures have given highly conflicting results, attributing the discrepancies to differences in soil type, water chemistry, and other factors. The problem of having to use dissimilar ponds

Sycamore anthracnose shoot-blight stage showing the sudden death of the expanding shoots and the immature leaves. The symptoms are often mistaken for frost damage. (Photo by J. Cedric Carter.)

has been especially obvious. Frequently strip-mine ponds, borrow pits, farm ponds, and small impoundments had to be used, and results from these different sources compared with each other. The necessity for such choices of ponds lies in the high cost of constructing and maintaining large numbers of essentially identical ponds in the same place.

Last year the Department of Conservation constructed nine one-acre ponds for the Survey's use in Forbes State Park, Marion County. Survey aquatic biologists G. W. Bennett and D. H. Buck decided that the most important single experiment they could run was to test fish production in this series of nine ponds, situated side by side on the same soil type, with the same climate and, as far as the eye could tell, identical in almost every respect. The results, just tabulated by Dr. Buck, fully vindicate this test.

In these nine ponds fish production ranged from 177 to 335 pounds each; in other words, the best pond produced almost exactly twice as much as the poorest, with different ponds forming a graded series in between. Dissolved minerals, water transparency, alkalinity, and other pond conditions also showed a considerable range of differences in the nine ponds, but variations of these factors were of much less magnitude than differences in yield, and uncorrelated with them. These results pose a problem of paramount importance to all pond fisheries research: What causes this remarkable range of fish production in relatively similar ponds?

Certainly some as yet undiscovered factors are at work. Perhaps the amount of fertilization used was near a critical maximum point, to the extent that slight, chance build-ups of adverse oxygen or alkalinity conditions for just a few hours on occasional days caused unusual stunting in some ponds. Perhaps the chance establishment of extra-nutritious algae or other microorganisms contributed to unusual fish growth in certain ponds. The fish themselves may represent genetic strains having different growth rates. There are many other possibilities; perhaps a whole cluster of undiscovered factors produced these radical results.

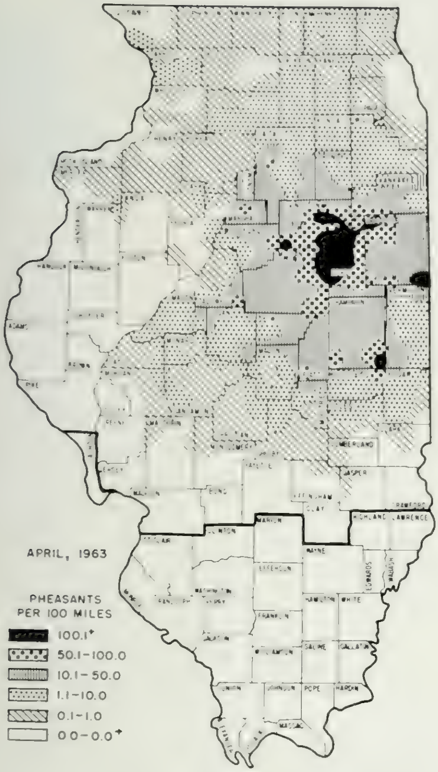
Whatever these factors are, until they are discovered and methods figured out to keep them relatively constant in experimental ponds, comparing fish production even from similar-looking ponds could be almost meaningless. This historic preliminary experiment has drawn Dr. Bennett and Dr. Buck into a most exacting yet necessary area of testing and investigation.

Pheasant Puzzle

Much speculation has existed concerning the factors influencing the distribution and abundance of ring-necked pheasants in Illinois. Although the species has lived in Illinois about sixty years, it has never established itself in the west-central and southern counties of our state. Its range is restricted to the northeastern third of the state, the area formerly covered by the last, or Wisconsinan, glacial lobe. Various theories have been offered to explain these restrictions of distribution. Some thought that land use was a dominant factor, others that too little calcium was present on areas of older soils, in contrast to the newer soils of Wisconsinan age, for eggshell and bone development. Still others felt that differences in weather in different parts of the state provided the answers to the puzzle.

Survey wildlife scientists have been investigating pheasants for many years to learn just what does or does not restrict the range of this colorful bird. The results of much of this work are summarized in the Survey's recent *Biological Notes* 51 by R. F. Labisky, J. A. Harper, and Frederick Greeley. Pheasants are most abundant in the heavily farmed cash-grain region of east-central Illinois, where at least half of the land is planted to corn and soybeans. Within this region pheasant numbers are greatest where about one-fifth of the land is in hay or pasture. Pheasants prefer the legumes and grasses of hayfields for nesting.

Chemical analyses of soils, grit, pheasant foods, eggshells, and tissues and bones of the pheasants themselves showed that ring-necks living on both old and new soils in the state obtain plenty of calcium for



Density of pheasants shown by the last statewide census. None is established below the heavy line.

their needs. This rules out calcium as a factor in limiting the distribution of pheasants in Illinois.

Weather is a complex piece of the puzzle. Counts of clutches and hatching in transplanted southern colonies of ring-necks indicate that high air temperatures do not restrict the southward spread of the bird by causing death of the developing chicks in the egg. In Illinois, few pheasants are victims of winter storms. Waste corn is one of their principal foods in winter, and they will scratch through more than a foot of snow to reach buried kernels and ears. During the nesting season, however, both unusually cold and wet, and hot and dry weather can cause a poor hatch of young.

There is some indication that weather adverse to pheasants may occur more frequently in southern Illinois and that this may be the determining factor in restricting the Illinois range of ring-necks. Wildlifer Labisky and his colleagues are now following up this lead.

Northward on the Wind

It might seem that by now the spectacular migrations of spring were over. The geese and most of the ducks have winged far to the north. The songbirds are passing through to the north or returning to nest from their southern wintering grounds. The last band of migrant birds, the insectivorous nighthawks, martins, and their kin, should soon complete this conspicuous annual passage.

Unseen by the casual observer, this late April-early May period heralds an even more fantastic migration of insects into the Midwest. Most abundant of them will probably be the potato leafhopper, *Empoasca fabae*, known as *fabae* for short. Last year, if your potato and garden bean foliage shriveled as if burned, and your alfalfa and clover yellowed and gave an unexpectedly low yield, *fabae* was the cause of it. Occurring in tremendous populations, these little green insects, each less than one-eighth of an inch long, suck the juices of plants and at the same time leave a residue of saliva that poisons the plant tissues. When freezing weather comes in early winter, our local populations of *fabae* die and the species disappears from this area.

Entomologists long suspected that *fabae* was a migratory species but it took years to ferret out the story. Many difficulties were encountered. First, *fabae* has 40 or 50 close relatives in the Midwest, most of them overwintering in Illinois. Identifying characters were needed to be sure which specimens were *fabae* and which were other species. Using special methods of preparation, minute characters were eventually found that provided this vital information. The second difficulty was the tremendous task of getting collections often enough and in enough localities to know what *fabae* was doing over the entire section of North American between the Appalachians and the Rockies and from the Gulf Coast northward. This was solved by one of the most remarkable cooperative

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efforts in entomological history, in which several hundred entomologists from about thirty states and adjoining Canada made coordinated series of collections for a period of about five years.

Early hypotheses thought that *fabae* overwintered in the West Indies, Yucatan, or southern South America. The cooperation of about 50 entomologists and several organizations from these areas helped to demonstrate that what we had been calling *fabae* south of the United States was not *fabae* at all, but a whole cluster of distinctive species.

The results of this wide-ranging investigation, funneled through the Survey laboratories and spearheaded by Survey entomologists G. C. Decker, H. B. Cunningham, and H. H. Ross, has finally given a clear picture of the *fabae* story. *Fabae* overwinters as small scattered populations in a narrow strip along the Gulf Coast from southern Texas around to and across central Florida. In February odd females are carried northward by local winds. By May new population centers have become abundant in the Mississippi delta as far north as Greenville, Mississippi, and Little Rock, Arkansas. Feeding on the tender spring growth of many plants, especially sweet clover and vetch, these delta populations rapidly build up to tremendous numbers. The cyclonic winds normal to late April carry *fabae* further northward, usually in an easterly arc, peppering Illinois and surrounding states, first lightly, then heavily, with these migrant insects. By mid-May (if the weather has been favorable for *fabae* production further south) Illinois is literally plastered with thriving colonies of *fabae* which by June can produce destructive populations on many garden and farm crops.

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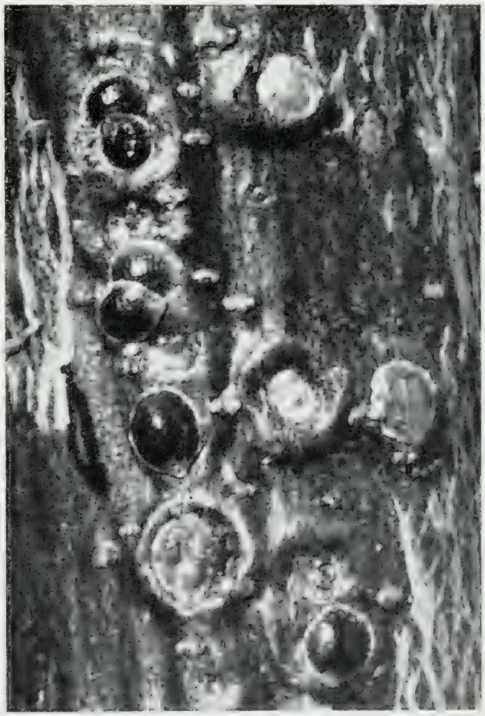
MAY 1965 NO. 31

Golden Oak Scale

Although the fact is not generally recognized, Illinois' ornamental trees and shrubs are attacked by a tremendous array of insects. Oak trees alone are fed on by several hundred species, some eating the leaves, some sucking the juices, some boring in the wood. The number of these pests increases constantly. In spite of the most rigid federal and state inspection of nursery stock, an occasional new pest gets by, becomes established usually around the port of entry, and eventually may spread through the entire country. A reminder of this is our second record of the golden oak scale, called *Asterolecanium variolosum*. One record was found in the Chicago region thirty years ago; this past year another serious infection occurred, again from northern Illinois (Lake County) on pin oak in a nursery.

Since 1836, when it was originally discovered in France, this oak pest has damaged oaks in Europe, Africa, New Zealand and Australia, Chile, Canada, and the United States. In America this insect was first found in Washington, D.C., in 1878; by 1913 it had spread to California. While it has yet been of only rare and local consequence in Illinois, with increasing shipments of nursery stock from region to region and with a great demand for oak seedlings for homes and towns, this scale insect could become of considerable importance.

The Survey's scale specialist, Dr. L. J. Stannard, points out that although each scale is less than one-tenth of an inch in diameter, the species is easily recognized by the enlarged ring of bark around each scale. The scales begin life as tiny naked crawlers that search for a suitable spot to feed. Each crawler then settles down, sinks its needle-like beak into the tissues of the branch, and stays there for life. A series of tiny glands along the insect's back secrete the hard wax scale that forms a roof over the entire insect. The insect's feeding causes the bark around the scale to enlarge



A colony of the golden oak scale on a pin oak branch. The crater-like structures are caused by the bark growing up in a ridge around each scale; this simple pattern becomes confused when several scales grow close together. Each of the large scales is less than 1/10 of an inch long. (Photo by Survey Photographer Wilmer Zehr.)

into a ring, so that the stationary scale seems to sink into a pit of bark. The scale itself is greenish brown to golden yellow. Colonies of scales may contain so many individuals that they reduce the flow of sap and kill the twigs. Survey entomologist Dr. J. E. Appleby, who is keeping watch on the possible spread of this tiny insect, reports that the golden oak scale has not become established in the native woods of the United States. So far it has occurred only on trees in towns and in groves of planted stock.

Hidden Threat

When the papers report the capture of a rabid skunk, everyone in the neighborhood worries. When no rabid animals are reported for a long time, few people give even a passing thought to the disease. Lack of news seems to lull us into a sense of security. Several years ago Survey wildlife investigators wondered just what was the relation between reported incidence of rabid skunks and the presence of rabies in the skunk population. In 1958 project leader B. J. Verts began making annual collections of striped skunks in Carroll County. Brains and salivary glands from these skunks were tested by mouse inoculation for the presence of rabies virus.

Results from this checking, now through its seventh year, give a graphic picture when compared with the number of rabid skunks reported from other sources. During this seven years only two rabid skunks from Carroll County were reported to the Illinois Department of Agriculture, one in 1960 and one in 1961. In the Survey's samples, a total of 336 skunks were tested, and of these twenty-nine had rabies. In 1958 and 1959 no one reported rabid skunks, and eighty-five tested skunks showed no rabies. In the two years that rabid skunks were reported by others, in 1960 wildlifer Verts found two rabid skunks out of sixty-seven tested, in 1961 eleven rabid skunks out of forty tested. In the next three years Verts found rabid skunks each year, with a relatively high percentage in both 1962 and 1963 (ten out of seveny-one, and five out of forty-two).

These figures suggest that there was indeed a rapid increase of rabid skunks in Carroll County in 1960 and 1961, that the phenomenon of rabid skunks was novel at that time, and reports of them did reach reporting agencies. It would seem further that afterwards public interest in the disease waned and enthusiasm for relaying reports decreased. Whatever these human factors of observing and reporting may be, these data show clearly that random reporting of rabid skunks by interested persons does not give an accurate picture of the presence or prevalence of rabies in skunk populations.

Tick and Chigger Warning

As hikers take more and more to the woods, Survey entomologist L. J. Stanard again warns out-of-doors enthusiasts to be on guard against wood ticks and chiggers. Chiggers will be out in southern Illinois from about mid-May until early October, in the northern half of the state from early June until late September. As preventive measures against chiggers, Survey entomologist W. N. Bruce recommends a solution containing one part benzol benzoate in nine parts of light mineral oil, rubbed on the feet and legs, under the belt line, and around the groin each day before going into the fields or woods.

Wood ticks will be active from now until August. They can transmit the parasite causing Rocky Mountain spotted fever which at some time or another has been detected in every county of the state. Preventive shots were formerly considered the only sure remedy against this disease, but Dr. N. J. Rose, State Department of Public Health, Springfield, Illinois, has informed us that spotted fever can now be treated by oral doses of the tetracycline antibiotics or chloramphenicol, after the disease symptoms appear. Your doctor can obtain details of this revolutionary new treatment from Dr. Rose; suspected ticks can be identified at the Survey.

Bidrin

Ever since Dutch elm disease proved to be such a scourge of American elms, the

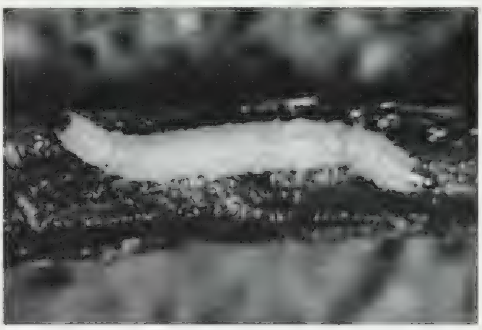
country's favorite shade trees, investigators have been trying to find what would seem to be the perfect remedy: some substance that could be injected into the tree to prevent or to cure the disease. Survey scientists are testing two sets of these internal poisons called systemics. One set includes compounds aimed at killing the fungus pathogen of the disease. This set has shown only limited promise. The other set of compounds is aimed at killing the little bark beetles that carry the disease organisms from infected to healthy trees, before the beetles can effect introduction of the fungus into a healthy tree. One of these, called Bidrin, showed some promise, and starting in 1959 Survey entomologist L. L. English and plant pathologist Walter Hartstirn have run field experiments with it to test its efficiency. They found that 8.6 per cent of the Bidrin treated trees died. Also, the chemical was sufficiently toxic to the trees that it killed an additional 13.6 per cent. The loss of treated trees, therefore, amounted to 22.2 per cent, whereas untreated trees in the same area sustained a loss of only 21 per cent. Because of these unfavorable over-all results, Bidrin is not recommended as a disease control.

Some workers in other states have reported more favorable results, whereas other workers have reached the same conclusions as Dr. English and Dr. Hartstirn. In an effort to resolve this problem, the United States Department of Agriculture is conducting a large experiment in each of four cities that are not applying any other insecticides in attempts to control Dutch elm disease. The cities selected are Toledo and Cleveland, Ohio, Detroit, Michigan, and Moline, Illinois. Dr. Hartstirn will be working closely with the Moline experiment. Until the results of these tests are in, the Survey recommends the same procedures it has in the past for controlling Dutch elm disease.

Resistance Detector

The northern corn rootworm is a perennial arch-enemy of corn in the Midwest. Actually the corn rootworm does not consider corn an enemy. Quite the opposite. The small, wormlike larvae adore the small roots of the corn plant and feed on them voraciously. If present in sufficient numbers these little larvae will eat off all the rootlets, and the corn plant either dies of desiccation or is blown over and lodged with the first strong wind. When full grown these larvae transform to small green beetles less than a quarter of an inch long. In a new field continuously planted to corn it takes the rootworms about three years to build up to economic densities.

It was early discovered that rootworms do not succeed on legumes, hence in the pre-DDT days farmers rotated corn and legumes and achieved a quite satisfactory control of this pest. The chlorinated hydrocarbon insecticide gave such effective control of rootworms that for the last decade and a half corn could be grown year after year in the same fields. Especially in canning-corn and seed-corn production, this possibility opened almost a new economic outlook in areas of high-yield land such as central and northern Illinois. The first rumblings of trouble about corn rootworm control came from the intensively cultivated, irrigated corn land of eastern Nebraska. It was found there that another pest rootworm had developed populations that were resistant to chlorinated hydrocarbons. Two years ago Survey entomologist J. H. Bigger found



Larva of the northern corn rootworm on corn root. This larva is about ½ inch long, with a hard black patch at its posterior end (to the left in this picture), and a hard black head and a small dark shield behind it. Otherwise the larva is whitish and membranous. (Photo by H. B. Petty.)

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a few fields in Illinois in which our northern corn rootworm had developed the same kind of resistance. Last year Survey entomologist R. E. Sechriest found several more fields having resistant beetle populations.

Resistance is measured by bringing collections of adults into the laboratory, subjecting them to known, minute quantities of various insecticides, and determining the dosage that is lethal to 50 per cent of the sample. Technically this is known as the L.D.50. For his tests Dr. Sechriest uses a solution of aldrin in acetone. Individuals from populations with no resistance may be killed by only .002 microliters of this aldrin solution; they are still considered susceptible up to an L.D.50 of .029 microliters. If it takes more than this to kill half the population, the latter is considered to be resistant and if it takes 8.0 or more microliters, the population is considered highly resistant. One Illinois population had an L.D.50 of 24.0 microliters. This population was therefore 12,000 times as resistant to aldrin as completely nonsusceptible populations.

Highly resistant populations have now been detected in Carroll, DeKalb, and Lee counties, and a large number of them in Woodford County, primarily in the El Paso area. Dr. Sechriest points out that other fields having highly resistant rootworm populations undoubtedly occur in the state, but the symptoms are either not noticed or reported too late in the year to make a test. If you have a field that has been in corn continuously for five or six years, if it has been treated every year with insecticides, if a lot of rootworm adults are present in the field, and if some lodging of the corn is noticed, then you may have resistant rootworms. We would appreciate reports of such circumstances.

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JUNE 1965, NO. 32

Virus Headaches

The newest set of potted and benched plants in the Survey greenhouses is a series of gladioli so spotted, streaked, or stunted that a florist would look away in disdain. These are plants affected by viruses being studied by Survey plant pathologists J. L. Forsberg and Walter Hartstirn.

Fungus and bacterial diseases are no longer a problem to the informed gladiolus grower in Illinois, because good controls for them are known. This is not true for the many virus diseases of gladioli. Some are relatively rare or cause little commercial damage, but two are of important economic status. *White break,* caused by the cucumber mosaic virus, produces white streaks and blotches on leaves and petals; it disfigures the flowers beyond commercial use and may ruin whole fields of gladioli. *Stunt* causes the plants to grow only a third of their normal height with a very short flower spike; it acts like a virus disease, but a causative virus has not yet been isolated. Year after year *stunt* causes substantial losses by affecting scattered plants throughout the entire gladiolus-growing area. Dr. Forsberg points out that corms carrying viruses usually look quite normal, hence the buyer has no way of knowing whether or not he is getting diseased corms.

Little is known about these gladiolus viruses. Plant viruses are usually transmitted from plant to plant by insects, but which ones are involved here we don't know. Frequently reservoirs of the viruses are present in weedy plants and are constantly transmitted from these to the economic host, but we know very little about this phase of gladiolus viruses. It would be extremely helpful if diseased corms could be identified and culled from planting stock. These are some of the first problems that Dr. Forsberg and Dr. Hartstirn will be tackling in order to get further leads that will help to control these diseases.

Big Waters

This year one of Illinois' largest "inland" lakes will start filling up. This is the Carlyle reservoir on the Kaskaskia River. The dam stretches across the river at Carlyle, and the reservoir will extend across Clinton County and well into Fayette County. This summer the reservoir should fill to about 5,000 acres: in 1966 it should

The dark red King David gladiolus streaked with *white break.* (Photo by J. L. Forsberg.)

fill to near its final average size of about 26,000 acres. Construction has started north of Shelbyville on a similar reservoir about half the size of the one at Carlyle; plans center around finishing construction during the early 1970's.

The Carlyle reservoir will be physically unlike any other body of water in the state. It will be quite wide, but very shallow on either side of the main channel. Furthermore, it will not be a relatively still lake but will have the main current of the river flowing through its entire length.

Under proper management, the lake could have a tremendous potential for both recreational and commercial fishing. Survey aquatic biologist R. W. Larimore points out, however, that we have almost nothing in the way of guideposts on which to build a management program. The great bulk of fishery investigations have been on either cold-water lakes, small ponds and impoundments, or the large, deep, TVA lakes. It will be necessary to study the new lake very closely to find out its fish-food potential, the effect of agricultural and industrial pollution, the effect of aquatic vegetation, depth and bottom on fish production, the relative growth of desirable kinds of fish compared with "weed" fish.

To get a background knowledge that should be useful as a start in these lake studies, Dr. Larimore and his colleagues have been making systematic fish collections from all sections of the Kaskaskia River for the past five years. They have found that certain kinds of fishes breed in the main stream of the river but that other kinds, especially carp, buffalo, gizzard shad, and sunfish are especially abundant in the pools along the flood plain of the river. Certain of these species are also abundant in the main part of the river, but it appears now that the species actually reproduce in the flood plain pools and that the river populations are constantly replenished from these sources.

This summer Dr. Larimore, in cooperation with the Department of Conservation, plans to expand this evaluation in Carlyle Reservoir itself in order to obtain fishery data about the lake as soon as it starts filling up. Information on this very early history may give the most valuable clues concerning future management of this large body of water.

When to Spray

The American housewife buys canned and frozen vegetables so free of insect remains that it is a relative marvel of the modern age. Why a marvel? Because every kind of vegetable grown for canning or freezing is attacked by many insects, and only a combination of vigorous and carefully planned insecticide applications plus inspection of the ripe product as it goes through the cannery make sure that these unwanted insects don't get into the can.

Hand inspection is getting more and more expensive and, in a large run when everything is going at top speed, is inefficient. If possible, the ideal is to bring in produce that has no insects on it. To attain control of this perfection requires the utmost in skilled control programs.

In Illinois the corn earworm and the European corn borer have been unusually difficult to control on late-planted sweet corn, one of Illinois' largest canning operations. Good insecticides are available, but their efficiency depends on their being applied at regular intervals during the egg-hatching period. Timing of application is particularly important with the corn earworm as this insect lays its eggs on the corn silk, and the newly hatched larvae average only 30 minutes on the exposed silk before entering the tip of the ear. On a big acreage where thousands of ears of corn must be treated on the right day, it takes some time to marshal the equipment, the crew, and the dusts or sprays to be applied.

In an effort to give the canner a head start in this planning, Survey entomologist W. H. Luckmann made careful studies of the time it took these insect eggs to hatch at different temperatures. He found that the eggs developed faster proportionately as the temperature increased, and according to an exact ratio between development

Location of the Carlyle and Shelbyville reservoirs. The lined areas represent the permanent conservation pools, the dotted lines the major flood control stages. (Map prepared by W. L. Taylor.)

and temperature. By keeping records of temperatures from the time of first egg laying, it was possible to know how much development had taken place and how much remained. Furthermore, a certain total amount of heat, expressed as heat units, is needed for egg development, and Dr. Luckmann devised a method of summing these heat units above a 54-degree basis to give a measure of the amount of development that had occurred. With a moderately accurate forecast of temperatures for the next 24 to 36 hours, the time of egg hatching can be predicted within very close limits. This gives the canner the guidance necessary to plan control operations in each field timed to the hatching of the young larvae.

Last year this technique of calculating heat units was used in timing applications of insecticides by three of the major canning companies in Illinois, who reported the best control ever obtained in their operations. Dr. Luckmann is working toward improving methods of temperature taking and temperature summing so that the method can be used more widely.

Fly-by-Night

During what hours do our millions of migratory songbirds travel? How fast do they fly? How far during one hop? These are questions that have puzzled ornithologists for years. The use of moon-watching, radar, and the recording of bird calls at night brought in some evidence. Comparing the radar and call-recording data, Survey ornithologist R. R. Graber noticed that the radar data suggested a daily migratory peak at 10 or 11 o'clock at night, decreasing soon after, and indicating that most birds were down by 2 A.M. The call recording, on the other hand, indicated a flight peak at midnight, continuing with little change to predawn, with landing at first light. The only way to get at this answer was somehow to follow individual migrating birds from the moment each left one area until it landed at the end of its flight.

Radio tracking seemed to be the most feasible answer. Could a transmitter be designed small enough that it would not bother the flight of a small bird? Survey wildlife expert and electronics engineer W. W. Cochran, designer of portable transmitters for deer, ducks, and many other species, set about to design such an instrument — small enough to be carried by a bird, strong enough to emit a receivable signal (a series of beeps), and with enough battery power to last several days. He finally came up with a satisfactory model that weighed only one-tenth of an ounce. Then came the problem of how to fasten it to the bird without interfering with its flight movements. This was solved by a neat way of gluing it to the back just behind the head.

Early trials were discouraging. Birds were trapped, radios attached, the birds were released, and then followed by directional receivers mounted in the Natural Resources Building, in the Graber home (this one monitored by Mrs. Jean Graber), and one mounted in a truck. A charter plane with a special receiver was gassed up and ready to take off at a moment's notice. The birds, no longer visible by sight, could be followed in their movements around Urbana by "radio fixes" from these monitoring stations. Some birds

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refused to migrate before the batteries ran down. Other birds, watched continuously for hours, slipped away and were "lost" to the radio receiver.

Finally on May 6th a freshly tagged Swainson's thrush took to the air in Urbana at 7:50 P.M. C.S.T. Strong signals told watchers Cochran and G. W. Swenson III in the building and Jean Graber at her station that the bird was in the air. The two stations obtained successful "fixes" on the bird and determined immediately that it was heading northwest. They phoned Dr. Graber, waiting at the airport. He and the pilot jumped in, were off the ground immediately, and soon had located the bird. The bird flew at about 40 mph, the plane had a stalling speed of 60 mph, hence the pursuers had to occasionally circle back to get behind the bird, but were able to follow it and plot its course with great exactness. About midnight, approaching Moline, came a ticklish decision: Would the bird fly much longer? If not, the plane had plenty of gas; if it flew very much further, there were no airfields with gas pumps open after midnight ahead on the projected flight of the bird. They decided to refuel at Moline and fretted 40 minutes on the ground waiting for someone with a key to the gas pump, etc., etc.; finally they were on their way again. Following a projection of the course the bird had flown, they located it again within an hour, only a fraction off its earlier course. At 4 A.M. C.S.T. the bird landed north of Rochester, Minnesota. It had flown for 8 hours and 10 minutes at 43 miles an hour. The straight-line distance between Urbana and the landing spot is 350 miles; the bird had flown in a very faint arc so that it had actually covered 353 miles. As the pilot said, "I couldn't navigate that well myself."

With the tracking method proven workable, these researchers feel that we can finally get definite answers to some of the long-asked questions on songbird migration.

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JULY 1965, NO. 33

Fishes in Illinois

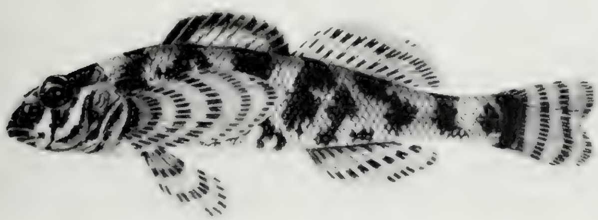
Fisheries investigators, limnologists, and naturalists will welcome Survey ichthyologist P. W. Smith's newest publication, *A Preliminary Annotated List of the Lampreys and Fishes of Illinois (Biological Notes No. 54)*, now available from the Survey. Up-to-date scientific and common names and the general range of each species are given for the 177 different kinds of fishes known to occur in Illinois waters, including southwestern Lake Michigan. Dr. Smith has also included information about thirty-five species either formerly recorded from Illinois, periodically introduced but not persisting in Illinois, or occurring in neighboring states with the likelihood that eventually they will be found at least sporadically in Illinois.

Considering the tremendous physical changes in the lands of Illinois during the past seventy years, it seems remarkable that only six previously recorded native species have been extirpated in the state. Some of these have not been recorded in Illinois since 1900, others have been found as recently as 1932. Many other species were once fairly widespread in the state but now apparently persist only in scattered small areas unusually free from disturbance.

Maybe They're Hungry

In tracking down the cause of unhealthy conditions in trees, Survey plant pathologists found that ailing trees frequently harbored no disease but "snapped out of it" when plant food was added to the soil. Checking the literature for definite clues concerning shade tree fertilization, Survey plant pathologists E. B. Himelick and Dan Neely found that remarkably few studies had been made on the problem. Early in 1963, with the aid of Webster R. Crawley, Jr., head of applied research at the Morton Arboretum, Lisle, Illinois, they treated plots of pin oaks, white ash, and honey locusts with various types of nutrient elements including nitrogen, potassium, phosphorus, plus minor or trace elements. These nutrients were applied as liquids or solids put in holes made in the soil, by injecting liquid fertilizers in the soil, by surface broadcasting, and by spraying on the foliage.

After two years of treatment, some intriguing results are already apparent. In the loam soils of northeastern Illinois, only nitrogen has had a marked effect as an added nutrient. Sprayed on the foliage, it has produced little or no growth gains but



The Harlequin darter, new record for Illinois, from the middle Embarras River in Cumberland and Jasper counties, is known otherwise from old records in Kentucky and Indiana and recent ones from the Ozarks of Arkansas and Missouri. (Illustration by Mrs. Alice Prickett.)

both surface broadcasting and dry and wet applications in the soil have been equally effective. Because it is both effective and cheaper, surface broadcasting can be recommended as a satisfactory type of application. In other types of soil having different chemical deficiencies or different characteristics of percolation from the loam soil at Lisle, the results might very well be different.

At Lisle, nitrogen added at the rate of six pounds per thousand square feet resulted in increased tree circumferences of 39 per cent for white ash, 52 per cent for pin oak, and 73 per cent for honey locust. The investigators point out that, especially in new developments, undesirable or short-lived trees are often planted for shade because they make unusually rapid growth. They reason that this may not be necessary, that some of the long-lived desirable tree species might be used in these plantings and the desired growth promoted by fertilization. They point out, however, that our knowledge of the responses to fertilization of different kinds of trees in the various soils found in Illinois is far too meager to make general recommendations.

This promising early start is now being expanded to test other trees and other soils. In the meantime, helpful information on types of fertilizers, rates of application, and application equipment, is available in the summary of their studies just published as the Survey's *Biological Notes No. 53*.

Losses and Profits

What is a good year and what is a rough year, dollar-wise, when it comes to insect losses? Gathering data from farmers, extension staff, and county agents, in addition to information in their own files, Survey entomologists H. B. Petty and his colleagues came up with a practical answer to this question when they finally tabulated the number of acres of field crops treated for various insect pests during 1964. In terms of insects, 1963 was considered a rough year: in Illinois over 5,800,000 acres were treated, as a result of which farmers saved crops valued at over twenty three million dollars plus the cost of treatment. From the standpoint of pest insects 1964 was a good year, with fewer outbreaks reported. During 1964 only about 5,200,000 acres of field crops needed treatment, as a result of which farmers saved crops valued at nearly nineteen million dollars plus treatment costs.

Acres of Field Crops Treated with Insecticides and Estimated Profit from Treatment, Illinois, 1964

Crop and Insect	*Acres Treated*	*Estimated Profits**
Clover and Alfalfa		
Potato leafhopper	25,650	$ 51,300
Meadow spittlebug	19,933	19,933
Pea aphis	15,110	22,665
Clover leaf weevil	11,224	16,836
Variegated cutworm	7,291	12,759
Sweet clover weevil	3,875	31,000
Corn		
Soil insects	4,091,125	16,364,500
Cutworm	165,707	828,535
Chinch bug	48,017	48,017
Fall armyworm	46,593	46,593
European corn borer	28,247	98,865
Corn leaf aphid	11,136	22,272
Soybeans		
Green clover worm	24,270	60,675
Bean leaf beetle	17,078	25,617
Clover root curculio	1,020	5,100
General		
True armyworm	466,578	656,926
Grasshoppers	219,626	463,957
1964 Total	5,202,480	$18,775,550
1963 Total	5,815,197	$23,197,432

* Over and above treatment costs.

Pheasants and Weather

One of the most puzzling questions that continues to plague wildlife management is the failure to establish good pheasant populations south of U.S. highway 36 in Illinois, Indiana, and Missouri. Lack of calcium in the soil, non-hatch of eggs due to excessive temperatures, and excessive predation have been suggested as reasons why the southern area is unsuitable for the persistence of pheasants, but intensive study of each point has failed to indicate that any of these are limiting factors.

Dr. Hepner (seated) and Dr. Ross comparing notes on leafhoppers. These are some of the ten million specimens in the Survey's research collections. (Photo by Survey photographer Wilmer Zehr.)

Taking another tack, Survey investigators have been taking a close look at Old Man Weather for possible clues to the puzzle.

Renowned pheasant-productive areas in the Midwest include eastern South Dakota, northeastern Nebraska, north-central Iowa, southwestern Minnesota, the northern part of east-central Illinois, and the thumb of Michigan. Survey wildlife specialist W. R. Edwards plotted the average monthly temperatures and rainfall for many areas in the Midwest and found that areas of good pheasant range had a conspicuous common denominator — all had higher rainfall during the summer months and lesser rainfall during the cold winter and early spring months. Pheasant strains introduced successfully into North America appear to have come from the plains area near or north of Shanghai, China, and this area has very low precipitation during the cold winter months but high monsoon precipitation during the summer months. The inference is that our pheasant strains in their long evolution in cooler areas of China became adapted to relatively dry winter conditions and may be unable to persist in southern Illinois areas where the winter precipitation is markedly greater than that of the prairies and central plains to the north.

By contrast, pheasants seem to do well in the humid coastal area of the Northwest where the summers are dry and the winters wet, but there the winters are much milder than in southern Illinois.

What we may need for southern Illinois is a different strain of pheasant adapted to a cold wet winter. Wildlifer W. L. Anderson points out that there are probably pheasant strains in provinces of central and southern China that might fit these requirements but that under existing conditions it is almost impossible to obtain breeding stock from specific areas because of the present state of world politics. Also, suppliers not acquainted with the real nature of the problem might well be tempted to substitute birds from tame stocks whose immediate ancestry was not from the regions specified. Such birds might not survive at all in the wild. The ideal solution would be to get birds through a scientific field party but at the moment this avenue of approach seems out of the question. As a future lead, it might have great possibilities.

Fussy about your food?

When an insect is damaging some crop or plant, a first concern is: Will it spread to other kinds of plants and damage them also? Many times the answer is, "No." The phlox bug feeds on no other kind of plant, pine sawflies feed only on pines, and asparagus beetles feed only on asparagus. These are examples of the fussy feeders. More kinds of insects each feed on any one of a group of related plants. Chinch bugs, armyworms, and grain aphids will feed on any one of many kinds of grasses, including oats and corn. Cabbage loopers will feed on cabbage, cauliflower, Brussels sprouts, and their relatives. These are the semi-fussy feeders. Some of the grasshoppers and certain other insects will feed on almost any green plant. These are the general feeders. It is important to know the feeding habits of an injurious insect in

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order to predict whether a particular outbreak will spread to neighboring crops, shrubs, or trees.

Survey entomologists now have a detailed knowledge of the food habits of almost all the agricultural insect pests, always excepting newly introduced species. They have learned the food habits of many of the larger nonagricultural insects that chew foliage and are fairly easy to rear. Until recently one of the biggest blanks in our knowledge of insect dietaries has been the food preferences of small leafhoppers that suck the juices from vines, shrubs, and trees. These pretty little leafhoppers, mostly only an eighth of an inch long, may be so abundant as to turn the leaves of elm, sycamore, Virginia creeper, or grape completely white, having sucked the contents from the green chlorophyll-bearing cells of the leaf. It is possible that some of these sucking insects are vectors of tree diseases.

In order to find out the biological relationships of the 500 different Illinois species comprising this tree-leafhopper group, Survey entomologist H. H. Ross has been making leafhopper collections on every species of woody plants in the state. So far, about 400 species have been associated with definite hosts. Some species feed on only one host, such as bur oak, redbud, grape, or poison ivy. Other leafhopper species feed on a variety of related hosts such as any of the lindens, any of the white oak group, or any of several elms; other leafhopper species feed on domestic apples, crab apples, or red haws. Practically none normally feeds on wider array.

A complication in host preference has been the discovery that the same kind of leafhopper may prefer a different host species in different parts of the country. To get an insight into this, Dr. Ross has been collaborating with Dr. L. W. Hepner, leafhopper specialist at Mississippi State University. Dr. Hepner spent May and June at Urbana where he and Dr. Ross coordinated their identifications of this difficult group of insects and made plans for the coming summer's program on this intriguing leafhopper study.

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AUGUST 1965, NO. 34

Careful with That Tree!

Are you planning to build a house on some wooded lot and keep the trees for a natural setting and shade? Or are you adding to your home and wanting to avoid damaging shade trees clustered around the dwelling? If so, extreme care must be taken that construction practices do not harm or kill your favorite trees.

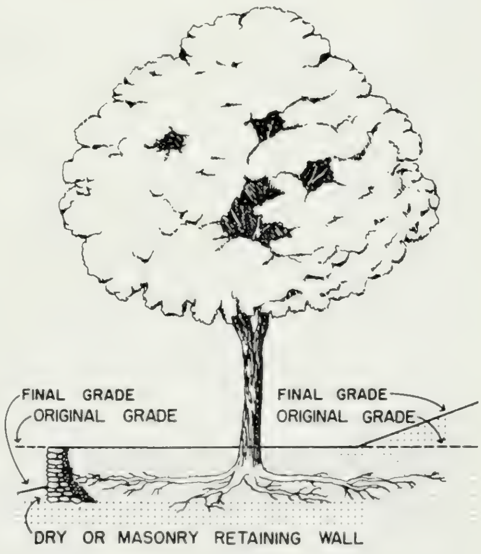
It was long thought that the chief construction damage resulted from cutting the root systems of trees during excavations for basements or driveways, but Survey plant pathologist D. F. Schoeneweiss points out that, although it can produce serious injury, direct root damage is not the most serious problem. The most common and least obvious construction damage results from changes in soil aeration.

Every established tree has a network of roots a certain critical distance beneath the surface of the soil, at a depth to give the tree the correct amount of root aeration. If earth fills are added above the natural soil level, if the soil is compacted by the weight of heavy machinery or heavy loads of supplies, or if the drainage is upset and the water level rises, the "breathing" from the roots is upset and the root system is irreparably damaged. With its root system damaged, the tree may wilt, staghead, become increasingly susceptible to disease and insect attack, and gradually die. White oak, beech, tulip tree, linden, and the conifers are particularly sensitive to changes in soil aeration.

Construction damage of all types can be prevented or minimized through adequate protection and care of established shade trees by the builder or contractor. In his recently completed summary of practices useful in avoiding construction damage, Dr. Schoeneweiss offers directions for the protection and care of trees during construction, and he outlines various devices that will protect trees from the adverse effects of either lowering or raising the soil level if the lot is to be regraded. These aids to the trees must be planned carefully and installed before the construction is done or the grade changes made. This information may be obtained by writing to the Survey.

And Now It's Starlings

The wood duck has always been cherished by Illinoisians. When its numbers



One of Dr. Schoeneweiss' charts showing how to safeguard tree roots against changes of grade during landscaping.

and nesting sites on the Illinois River dropped to a low point in the 1930's, Survey biologist Frank Bellrose began one of his first waterfowl studies. He found that half the wood duck nests — made in natural cavities in trees — were destroyed by raccoons, fox squirrels, and bull snakes. One of the keys to greater wood duck numbers was apparent: safer nesting sites would produce more young.

The first efforts revolved around making nesting houses of rough-cut lumber. The wood ducks used these as readily as natural cavities, but unfortunately the predators could and did enter them just as easily. Because raccoons were the most important nest predators, attempts were next made to design houses that would exclude these mammals. After several years of experimentation an elliptical entrance four inches across and three inches high was found that permitted wood ducks to enter but excluded raccoons weighing ten pounds or more. (At the time of wood duck nesting most raccoons were at least this large.)

Fox squirrels and snakes were still a problem. To exclude them various types of sheet metal coverings were tried. An efficient type was finally developed, but the resulting wood duck house was cumbersome and expensive. This model led to designing a metal house made from air duct pipe and having a high conical metal roof. This proved extremely efficient in excluding predators; tinsmiths could build the nest house easily and it was relatively inexpensive. Thus in the 1940's the wood duck problem seemed completely solved. Wood duck numbers increased appreciably, and Bellrose and Survey technician Robert Crompton turned their attention to other matters.

But times change. About 1958 starlings destroyed a few wood duck nests and took them over. This situation worsened until by 1962 starlings had destroyed a sixth of the wood duck nests along the Illinois River and in 1963 this loss rose to a fourth.

Once more Bellrose and Crompton got busy on the wood duck nesting problem, this time in an effort to find a method of reducing the menace of starlings. A ray of hope lay in the disinterest of starlings in utilizing natural cavities with large openings. Large entrances in metal houses, however, would permit the entry of raccoons. In an effort to make the 3- by 4-inch elliptical entrance appear large, they drilled five 2-inch holes around it. Crompton's inspections of wood duck houses during the spring of 1965 showed, unfortunately, that this stratagem failed to deter the starling's interest in utilizing wood duck houses.

But, for the first time, Crompton found a reverse twist! Although starlings usurped 9 wood duck nests in houses, wood ducks usurped 15 starling nests for their own nesting purposes. Perhaps wood ducks are becoming more aggressive, or perhaps some unknown mortality afflicted these particular starlings. Besides this reversal, breeding starlings have decreased greatly in central Illinois since their all-time high in 1963. Temporarily, the wood duck-starling crisis has eased off.

Chain Pickerel

In an effort to add greater variety and more consistent fishing success for fishermen frequenting the increasing number of lakes and ponds in Illinois, Survey aquatic biologists are experimenting with chain pickerel. Naturally these fish are generally distributed throughout eastern United States and southern and eastern Canada, frequenting quiet weedy waters. Although not attaining the large size of related pikes such as the northern pike and musky, chain pickerel reach a length of over two feet with weights above three pounds. Adult chain pickerel are solitary feeders, lying motionless in wait for their prey and then capturing it in one quick lunge. Their food consists principally of smaller fish, spiced up occasionally with frogs, snakes, mice, and muskrats. When hooked they give a good account of themselves, and are one of the favorite game fishes of the eastern states.

Survey aquatic biologists D. H. Buck and C. F. Thoits first raised chain pickerel in small ponds at Dundee, using stock procured from Massachusetts. High alkalinity wiped out the pickerel in one pond but in

Adult (left) and larva or white grub (right) of the June beetle genus *Phyllophaga*. (Photo by Survey photographer Wilmer Zehr.)

two ponds they survived and reproduced. These fish were used for an initial 1962 stocking of the newly filled 160-acre lake constructed by the Department of Conservation in McLean County. There the pickerel have spawned and grown well. This year Dr. Buck hopes to discover how well they are succeeding in the face of competition from an abundant largemouth bass population in the lake.

In April of this year 20,000 chain pickerel arrived by air freight from Ohio and were stocked in three Marion County experimental ponds. Here Dr. Buck and his colleagues are now making regular observations on the pickerel, studying its life history, its efficiency as a predator when living with different combinations of smaller fish, its ability to compete with largemouth bass in the warm-water habitats of central Illinois, and its value as a sport fish.

Host Crossover

Reports this summer of heavy white grub damage to soybeans represent the story of a crop imported from a far continent and eventually beset by one of the insects native to its new home. From the time of their introduction from Asia early in the century until the late 30's, soybeans were remarkably free from insect pests. In 1938 came first reports of white grub damage to soybeans, more alarms were sounded in 1941, and by 1944 it was apparent that Illinois soybeans had acquired an insect pest.

White grubs are the larval stages of June beetles. June beetle adults feed in the spring and summer on the foliage of many plants, including oak trees, wild roses, elms, sycamores, walnuts, and a wide variety of broad-leaved herbs. The adults stay in the soil during the day, come out at night, fly about, feed on plant foliage, then at daybreak enter the soil, lay eggs, and repeat this daily cycle for several weeks. The eggs hatch into small white larvae, the white grub stage, and these feed on the roots of various plants, chiefly members of the grass family. For years they have been destructive to corn and pastures in the entire Midwest.

This is the general story of the fifty different kinds or species of June beetles occurring in Illinois, all of them natives of the North American continent and most of them widespread throughout the eastern half of the United States. When it was evident that white grubs were firmly established on soybeans, Survey entomologist J. H. Bigger enlisted the cooperation of his Survey colleague M. W. Sanderson, international specialist on June beetles, in an effort to find out how many different kinds of white grubs were involved and how much the soybean diet had affected their habits. They found that only one species of June beetle, *Phyllophaga rugosa,* had made the switch to soybeans. They also discovered that by 1946 the adults of this species showed a preference for soybeans. The adults come out early in the year before soybeans are up; during this period they feed on their old ancestral hosts, willow, rose, or whatever is available. When the soybeans do come up, the beetles desert their other hosts and eat soybeans.

Compared with many other insects (such as mosquitoes that can grow from egg to adult in seven days), most June beetles grow slowly, requiring three years to complete the full cycle from egg to egg.

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In *rugosa* and its allies, almost the entire population is synchronized as a single brood, with the adults appearing in large numbers every third year. Thus one year the adults are active, feeding, flying, and egg-laying, while the larvae are small and cause little root damage. The next year the larvae feed continuously throughout the growing season, attain most of their growth, and inflict the greatest damage to the plant. The third year little larval feeding occurs, the grubs change into pupae in the soil and these transform to adults before winter. These adults are quiescent until the following spring, when they emerge and start the cycle all over again.

Why only the one species *rugosa* of all our fifty native species of June beetles switched over to soybeans, we do not know. It exemplifies one of the important but poorly understood phenomena of nature that occurs every once in a while and is completely unpredictable. When such a change in behavior occurs, it seems to happen quite rapidly, in a matter of six to a dozen generations. At this moment only one thing seems certain: as more crops are introduced into different countries and as more potential pest species spread to different parts of the world, we are surely in for more and more surprises due to this innate ability of certain species of insects to become adapted to new crop hosts.

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SEPTEMBER 1965, NO [illegible]

Excuse Me Scratching

As pet owners well know, the warm, sultry dog days of late summer are just right for the build-up of fleas on dogs and cats. Chiefly involved are two different but closely related kinds of fleas, dog fleas and cat fleas.

Although these are the only two kinds of fleas that habitually become established in the house in Illinois, Survey entomologist and flea specialist L. J. Stannard has discovered that these are only two of some thirty kinds of fleas found in the State. Twenty-five of our species are native to North America, occurring especially on wild mice, shrews, squirrels, rabbits, raccoons, and colonial bats. Introduced species include the cat and dog fleas, the human flea, and the rat flea. The latter is the most infamous flea species, contributing in the Middle Ages to the dread black death of Europe because it transmitted the bubonic plague organism from rat to man. Although this flea has been found sporadically in Illinois, the disease is not established here. Centers of infection exist in the western states, but the danger of spread is always a possibility.

Fleas have a simple life history. Adult fleas lay eggs in the nest of the host. These hatch into white, legless, wormlike larvae that feed on fecal matter and detritis, then pupate on or in the soil. The adults emerge from the mature pupae and start the cycle again. Dr. Stannard points out that almost all fleas occur on only a single kind of animal host and the larvae can succeed only in the host lair. As a result, animals that do not regularly bed down in the same place or do not have lairs horses, cows, deer, elephants, and most primates — do not have special fleas.

The larva is the most vulnerable period in the life history and control measures are directed primarily against this stage. If you are concerned about fleas, you can obtain control directions from the Survey.

Deer Capture

One of the big problems in the Survey's deer-tracking project in southern Illinois is capturing live deer to which portable radio transmitters can be attached. Various types of box traps and corral traps have resulted in only scanty and inconsistent captures. The deer are smart enough to avoid most of these dangers.

A few years ago a new capture weapon appeared on the scene — syringe darts loaded with a knockout chemical, nicotine alkaloid. Darts were fastened to arrows

Cat flea specially treated and mounted on slide ready for microscopic study. Actual size about 1/8 inch.

and shot by long-bow or loaded into specially designed rifles. When the darts struck a deer, it released the alkaloid into the deer's blood stream and caused immobilization. The bows and arrows and the first rifles (powered by compressed carbon dioxide gas) proved unreliable. Next appeared a powder-operated syringe rifle and this proved to be an effective capture weapon.

Although an improvement over trapping, the syringe rifle method had serious limitations. It was often difficult to get close enough to the deer (these weapons do not have a long, accurate trajectory), and a goodly proportion of the captured deer did not survive the effect of the drug. In 1964 an added capture technique was tried, using the tranquilizer Diazepam, called Tranimul, previously used as a sedative on ailing or obstreperous domestic animals. Before attempting to capture deer, Survey wildlife biologists Gerald G. Montgomery and Robert Hawkins baited several sites with ears of corn. After deer had consumed most of the corn regularly at one of the baited sites, up to five ears coated with a Tranimul foam were mixed in with the bait.

Deer usually do not feed in open fields before twilight, and do not show the full effects of Tranimul until at least two hours after eating it. Hence deer captures were attempted six to eight hours after sunset. When tranquilized deer were found, frequently a member of the scouting team could jump off the truck and capture it by hand; if the deer started to move off, it was an easy target for the syringe gun. Sometimes even manually captured deer had to be injected with alkaloid to calm their struggles. It was found, however, that deer that had consumed Tranimul could be immobilized with only half the usual dosage of alkaloid, resulting in a greatly increased survival rate of the captured deer.

This combination of Tranimul, supplemented when necessary with alkaloid injection, is proving the most satisfactory method of capturing deer yet devised for the Survey's study area.

Down on Paper

In a highly agricultural, highly industrial state like Illinois, changes in the vegetation are phenomenal. Less than a hundred years ago nearly half of Illinois was covered with magnificent marshes and prairie. The typical prairie is completely gone; the few remnants that are still nearly native lack many of the typical prairie plants that once grew there. The marshes have fared little better, but even with these, the extensive prairie "sloughs" are no longer in existence. On the heels of man's commerce, many foreign plants have become established, some of them introduced intentionally but most of them weeds introduced accidentally, that plague the gardener and farmer.

When early in the century the possible magnitude of these vegetational changes became apparent, Survey scientists began recording Illinois' vegetation. Early reports described areas of tall-grass prairie, the vegetation of the dunesland along Lake Michigan near Zion, and the life of the unique sand areas along the Illinois River near Havana, Beardstown, and Meredosia. Later came extensive surveys of Illinois' forests and intensive studies of special vegetational types such as the hilltop prairies in central and western Illinois. With increased management of Illinois' forest lands for timber, game management, and recreation, more forest changes will need to be recorded. These past, present, and future studies are needed to portray the changing vegetation in our state.

But lists of plant names in technical publications can be a misleading record of the kind of living things that existed in a particular spot in past times. Some of the old identifications and distribution records were inaccurate or ambiguous, so that later we are not sure exactly what kind of plant the collector had before him. Taxonomists also find new characters often indicating that what older workers once called one species is really a cluster of species, each species often with distinct preferences as to where it lives. To make our records reliable, we need not a plant name in a publication but a plant speci-

Herbarium Assistant Joann Powell placing the 100,000th pressed plant in the Survey's cabinets. Witnessing this important event are, from the left, Dr. J. C. Carter, Head of the Botany Section; Dr. L. R. Heckard, University of California botanist and Secretary of the American Society of Plant Taxonomists; Dr. H. B. Mills, Survey Chief; and Dr. R. A. Evers, Survey plant taxonomist. (Photo by Geological Survey photographer Dale Ferris, kindly substituting for our own photographer on vacation.)

men housed in a collection or herbarium.

To obtain such a reliable botanical record of Illinois, the survey began a methodical program in 1927 to collect and preserve specimens of Illinois plants. For the past 19 years this has been the primary responsibility of Survey botanist R. A. Evers, who every year has collected in every one of Illinois' 102 counties. In this fashion he has recorded the spread of weeds and changes in the ranges of native plants, and he has greatly increased our knowledge of the Illinois flora.

Plant specimens are pressed and processed in special quick driers, then glued on sheets of tough white paper, identified, and filed in the Survey's herbarium cabinets. Dr. Evers points out that these dried plants are practically eternal — they last longer than the best paper and, in some of the older collections, have had to be remounted on new sheets when the old paper crumbled beneath the plant. August marked a signal point of growth for the Survey's collection of the higher plants of Illinois, with the addition of the 100,000th specimen to its herbarium.

Shades of Isaac Walton

Ever since the publication of Isaac Walton's *Compleat Angler* in 1653, fishermen have been trying to add to Isaac's tricks for outsmarting fish. The fish seem still to be supreme because angling success remains one of the most unpredictable of man's achievements. The Survey's aquatic biology team thinks that it may be on the track of a new wrinkle that might give fishermen a better prospect for coming home with a full creel.

The discovery was made at Ridge Lake, in Fox Ridge State Park, south of Charleston. For many years Survey biologist G. W. Bennett and summer specialist A. W. Adkins have been periodically draining and stocking the lake with different combinations of fish, then keeping an accurate creel census of anglers' hauls. Ridge Lake was last drained and censused in the spring of 1963, then reflooded and restocked with a known population of bass, bluegills, warmouths, and channel catfish. Fishing is permitted and all catches tabulated each year for June, July, and August. Fishing is usually best in June, slacks off somewhat in July, and takes a sharp drop by August.

For the summer of 1963 the total catch of bass, bluegills and warmouth was five

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pounds per acre per month, for 1964, nine pounds per acre — poor fishing.

A common method to increase fish sizes and fish populations is by fertilizing the water with commercial fertilizers. This produces a tremendous growth of small organisms, especially minute plants. These are eaten by small animals, which in turn are eaten by small fish, and these are eaten by large fish. This chain of events eventually produces an increased yield of fish. Fertilizing, however, almost invariably produces unsightly "blooms" of algae and other aquatic vegetation, ruining swimming, interfering with boating, and sometimes even making fishing practically impossible.

In trying to arrive at some way to improve the fishing in Ridge Lake, Dr. Bennett hit upon the idea of shortcutting the food-chain cycle associated with fertilizing, and adding to the lake food pellets that could be seen and eaten by the fish. Starting this June, fish food pellets were added to the lake almost daily. Preliminary observations indicate that the bluegills and channel catfish eat this food voraciously, the warmouths may eat some of it, but the bass probably eat none.

Creel censuses have been tabulated to date only for June and July but these show a phenomenal increase in angling success, with an average catch for June and July of 28 pounds per acre per month. This is considered excellent fishing. Furthermore, the good fishing continued into August, the anglers' doldrum month. The greatest increase in catch has involved bluegills and warmouth, but there has been some improvement in the bass fishing. Dr. Bennett points out that this is only one instance, and that the improved fishing may not be due to the addition of fish food. If it really is due to the fish food, he theorizes that perhaps the fish get used to their equivalent of three square meals a day, grow faster, are more healthy, and develop the questionable habit of eating all of the time. If gluttony among the bluegills is responsible for better fishing, development of the habit involves some extra expense, but Bennett and Adkins point out that this cost is probably much less than one per cent of the money spent by the anglers in reaching and enjoying fishing waters. Plans are now in progress to follow up this exciting lead with experiments testing the validity of present indications.

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Trip for Thrips Tips

This month Dr. K. Sakimura, Head of the Entomology Department of the Pineapple Research Institute of Hawaii, is visiting the Survey to consult with Survey entomologist L. J. Stannard and to see the Survey's famous thrips collection. Before coming to Urbana Dr. Sakimura spent considerable time at the other major world collections of thrips, in England, Austria, Washington, D.C., and California.

Although among the smallest of winged insects (they average about one-tenth of an inch long), thrips are extremely diverse in structure and comprise several thousand species, of which about 200 occur in Illinois. Their habits are equally varied — pollinating flowers, distributing fungus spores, feeding on many species of plants, and feeding on other insects and mites. In the latter role they are important natural controls for some of our economic insects, and some that feed on plant tissues are highly destructive to crops and ornamentals. Others that transmit virus diseases between crop plants are potential economic threats about which we know very little: in this field Dr. Sakimura is a leading authority.

Because of their small size, thrips are extremely difficult to classify, and in the past many of them have been misidentified. A number of economic thrips have become spread accidentally by man to almost all parts of the world. Every species has distinctive habits and a different economic potential, hence it is extremely important that workers in different parts of the world classify these tiny creatures accurately in order to keep the growing store of information straight. This visit is giving Dr. Sakimura and Dr. Stannard the opportunity to compare drawings and specimens and insure a better bookkeeping system for our knowledge of these tiny but abundant insects.

Food and Shelter

Current thinking has been that the cottontail rabbit flourished best in situations with the greatest mixture of different kinds of vegetation, especially when small areas of open grass and herbs, shrubs, and small trees formed a patchwork interspersed with small stands of trees. To test the importance of the different com-

Liothrips caryae, an Illinois oak and hickory thrips. (Photo of mounted specimen in Survey collection.)

ponents of this presumed ideal cottontail habitat, Survey wildlife biologists J. A. Bailey and R. J. Siglin began intensive observations in 1956 on such a tract in the Allerton Park 4-H area near Monticello, letting nature do the experimenting.

If left undisturbed, bare ground in this region is often covered first by a mixture of annual or perennial herbs such as fleabane, various asters, and related plants; this stage is normally followed by a grassy stage, then a shrub stage, and finally various tree stages. During this succession of habitat types, the proportions of the different kinds of vegetation will change, depending on the time that each patch got started. In 1956 the rabbit area at Allerton was composed of nearly 50 per cent herb stage, 20 per cent grass stage, 25 per cent various tree stages, and the remainder shrubs and hedges. Aerial photos were taken each year in late summer to record changes in vegetation.

From 1956 through 1961 the rabbits maintained rather large populations, but these decreased significantly during 1962 and through 1964. When the decreases in rabbits were compared with the change in vegetation, an interesting correlation emerged. After 1960 the herb patches decreased and by 1964 were less than 10 per cent of the study area; the bluegrass patches increased to 25 per cent and the patches of small trees increased to 35 per cent. In general appearance the entire area still looked as varied as ever, and to the eye seemed to be as good rule-of-thumb rabbit habitat as before. There was no evidence of undue rabbit deaths from predation or disease. The rabbit decline seemed due to a decrease of some item needed for successful rabbit reproduction and/or survival of young cottontails during the summer. The only obvious one was the decrease in the herb area.

Trapping results for one winter were plotted against habitat types and two correlations appeared from these figures rabbits were found most frequently in thickets such as multiflora rose and in patches of herbs. Thus the indications obtained from analyzing changes in vegetation types and from trapping in these vegetational types both suggest that herbs may be an important requirement of rabbits, either as food or shelter or both. Wildlifers Bailey and Siglin are now planning nutritional studies to see what role herbs as food may have played in the rabbit decrease.

Disease Detectors

One of the big problems of the plant pathologist is figuring out what is wrong with specimens sent in for identification. If they are flowers or stems with fungus or bacterial lesions, it may be possible to establish the identity of the disease rapidly. The same is true of woody samples showing well-known, characteristic symptoms. Everything else requires time-consuming diagnostic steps. Sometimes, after much work, it is discovered that no infectious disease is involved, that the trouble is caused by low temperature, drought, mechanical injuries, malnutrition, or some other circumstance.

About ten years ago requests for identification of diseased plant materials from municipalities, nurserymen, and home owners had built up to proportions that began to overtax the Survey's routines then in use. Survey plant pathologist J. C. Carter and his five colleagues organized an assembly line type of identification procedure, including record books set up to keep track of specimens going through complicated steps.

Samples consist of leaves, twigs, branches, roots, and sections of trunks. Most samples are of branches from trees that show wilt, especially elms suspected of having Dutch elm disease. Elm samples are run through a special set of procedures. Chips from woody samples that do not show certain telltale symptoms are cultured on special nutrient media in petri dishes. If the chips are infected with fungi or bacteria, these produce colonies that can often be identified. In many instances it is necessary to mount fruiting bodies or other parts of the colony and search for minute spores or other special structures using high power microscopes. If surface lesions are

Dr. E. B. Himelick examining cultured colonies of a tree pathogen. (Photo by Survey photographer Wilmer Zehr.)

present, bacterial or fungus material can be mounted on slides and usually identified without culturing.

For the last five years this routine has worked extremely well. Over 30,000 specimens have been identified from all parts of the state, representing diseases of practically all the common shade and ornamental species used in this area. As Dr. Carter points out, this has developed into a highly cooperative arrangement. Persons sending in material receive the diagnosis of the disease plus information on how it should be treated, if a treatment is known. The Survey gains valuable information on the ups and downs of the diseases of different hosts from year to year. Pertinent findings are published in appropriate journals so that they can be put to use by horticultural inspectors examining nursery stock, by nurserymen reordering plants and by landscapers planning new outlays or replacements.

The Mighty Mite

Just as fruit growers and entomologists began congratulating themselves on working out effective controls for insect pests of Illinois fruit, mites loomed as a threat to the State's 2½ million-bushel apple crop. These tiny spiderlike creatures, the two-spotted mite, the four-spotted mite, and the European red mite, produce populations as high as 500 per leaf. Their feeding removes the plant juices from the leaves, causes a bronze appearance of the trees, and reduces both size and quantity of fruit in the same way as would a severe drought.

During the past three years Survey entomologist R. H. Meyer has discovered that mite populations have reached higher numbers for longer periods of the growing season than formerly. This has several causes:

- Mites become resistant to chemical controls much more rapidly than do other pests. They have six to eight generations per year, hence resistant genetic strains have the opportunity of selection for and of taking over the entire population in one or two years.
- Mite populations resistant to practically every chemical formerly used and found effective against mites are appearing at least locally.
- Each mite species is not affected the same way by each miticide. A miticide that kills one or two kinds of mites may have little effect on another.

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• Mites are controlled to a surprising degree by relating predaceous mites that feed voraciously on the plant-feeding mites. Because the predacious mites are always less numerous than the leaf-feeding mites, and have slightly fewer generations per year, the predaceous mites do not build up insecticidal resistance as rapidly as their prey. For this reason control programs tend to reduce predatory species at a disproportionate rate.

In looking for ways to reduce mite populations, Dr. Meyer turned to several new leads. One was a special paraffin oil tried out this year in Illinois orchards and found to give greatly improved control of the European red mite. These oils must be refined to very exact specifications; if not just right, the oil itself is destructive to plant tissues.

Certain new fungicides were associated with low mite populations, hence were apparently exercising some control of the mites. In cooperation with U. of I. plant pathologist Dr. Dwight Powell, Dr. Meyer is now checking mite populations on test plots of all new fungicides, hoping that one of these may show promise of development as a mite control agent.

There is still the business of the predaceous mites. We know that they can be highly effective control agents for the plant-feeding species and that several different predaceous species are normally present in our orchard areas. How these populations of our friends can be manipulated to be of greater use presents extremely complex problems, because we know very little about their occurrence in areas surrounding orchards, their life histories, and their speed of dispersal and build-up after insecticidal knock-downs.

In facing this situation of new problems mounting and old answers being erased, Dr. Meyer says, "Oh well, there is nothing like a good mystery to solve."

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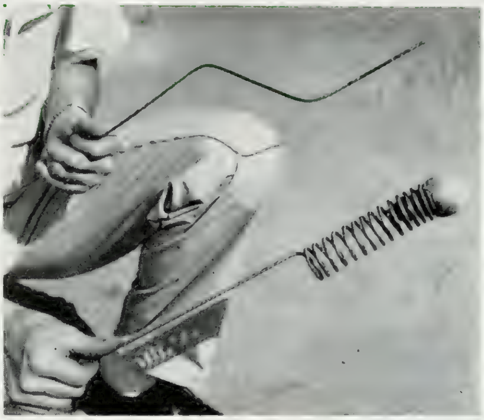
NOVEMBER 1965, NO. 37

Anybody Home?

One of the obstacles to getting an accurate census of the foxes and skunks in an area has been the difficulty of knowing whether animals were hiding in dens. These dens are deep and long enough, and twist around enough, that it is impossible to see an animal in them, and the animals themselves are extremely difficult to flush from the den. Sometimes an attached radio transmitter can be detected in the den, but, if the animal stays perfectly still, it is impossible to tell whether the transmitter is still on the live animal, if it has been torn off the animal and is simply lying on the floor of the den, or if the animal is dead.

In searching for some device to solve this problem, Survey wildlife researchers G. L. Storm and K. P. Dauphin hit upon the idea of constructing an artificial ferret. The ferret consisted of a piece of round, 4 mm. spring-steel wire 22 feet long. One end of the wire was bent into an L-shaped handle; the other end was wound into a coiled spring 1 foot long and 1½ inches in diameter. A round wooden plug was fitted into the end of the coil and was fastened with three wire staples. The coiled spring was inserted into the entrance of a den by one man while another forced the ferret deeper into the den by turning the handle.

They found this device extremely effective in flushing foxes from dens. Apparently the noise of the coiled spring slithering and rotating down the den tunnel was sufficiently strange and startling that most foxes moved out in a hurry, and could be captured either by hand or with a fisherman's dip net as they scooted out of the openings. Occasionally the hair of a fox would become entangled in the coiled spring and the fox was captured when the ferret was pulled out. Young foxes were especially easily flushed and captured.



The two ends of the mechanical ferret showing the spring portion that goes into the hole and the handle-shaped end by which it is turned. (Photo by G. L. Storm.)

Skunks were apparently not intimidated by the mechanical ferret because none was flushed after several trials. But the ferret did bother them enough so that they moved around in the den and it could be determined whether radio-tagged skunks within the den were alive or not.

Wildlifers Storm and Dauphin found also that their wire ferret could be used to find out many things they would like to know about these animal tunnels and dens, such as direction and depth of the tunnels and the number of tunnels in the den system. This knowledge of the "home con-

struction" of these animals might be extremely helpful in their later management.

Root Rot of Pine

For the first time in its history Illinois is face-to-face with one of the most destructive pests of pine. This is root rot, a disease caused by the fungus *Fomes annosus,* whose minute growing threads penetrate and rot the roots and kill the tree. Irregular, hard, fruiting bodies of the fungus grow out from the base of the tree trunk under the leaf litter at the ground line. Brown on top and white beneath, these structures produce innumerable tiny spores that are caught up and dispersed by air currents. If these spores land in a wound of a tree or on freshly cut stumps, they germinate and infect the tree. The growing strands of the fungus can pass from stump to tree or from tree to tree through root grafts and where roots touch. Once established, the fungus usually kills the tree in a year or two. It attacks all species of pine.

Root rot is suddenly a problem in Illinois because of the harvesting practices in pine plantations. In these plantations, trees are usually planted on 6-foot squares. In twenty or thirty years, when the trees reach about 8 inches in diameter, about a third of them are harvested for pulp and paper. This thinning is necessary for the continued optimum growth of the forest. But the thinning produces freshly cut stumps and sometimes falling trees cause wounds on uncut trees, and each stump or wound is an open invitation to root rot infestation. If root rot becomes established, it can wipe out the remaining trees of a thinned stand.

Illinois has about 65,000 acres of pine plantations, almost all of them in the southern fourth of the state and the great majority planted in the late 1930's. Thinning operations have started on many of these stands and it is obvious that root rot is spreading alarmingly. It threatens to annihilate many thinned plantations, both small and large.

Survey plant pathologist D. F. Schoeneweiss has been cooperating for the last year with the USDA Forest Service in assessing this problem. Dr. Schoeneweiss points out that the disease is serious in the north temperate zone of the entire world. Despite extensive studies in many countries, few control measures have been developed and even these do not give assured protection. Dr. Schoeneweiss hopes that some of the Survey's research on other tree diseases may give some clues for either cheaper or better controls of root rot of pine, and he will be working with Forest Service personnel in testing some of these remedies.

Next to Nothing

With the awareness that even the most minute quantities of the chlorinated hydrocarbons insecticides were stored and accumulated in living tissue, it was apparent that we needed finer insecticide detection methods than were available. Concerted study developed a series of tests by which an insecticide was changed into a colored pigment and these were matched against a series of calibrated colors. These tests were accurate at best to 0.1 part per million. A few years ago ways were found to utilize an "electron-capture" machine that gave astonishingly greater accuracy. In 1962, Survey entomologist W. N. Bruce assembled a modification of a commercial electron-capture rig that would detect amounts of chlorinated hydrocarbons as small as one ten-billionth of a gram.

In the meantime a new spectrum of insecticides was coming into common use. Especially important were the groups of insecticides called organophosphates and carbamates, together with certain compounds called synergists that are not in themselves effective insecticides but which increase the efficiency of certain other insecticides. These new compounds, while not as long-lived as the chlorinated hydrocarbons, are persistent enough that we need to know how long quantities of them persist in soils and plants.

Here we met a road block. The electron-capture method, so effective for the chlorinated hydrocarbons, gave extremely poor analyses for some of these new pesticides.

In efforts to resolve this problem, Dr. Bruce rigged up a new electron-capture system using the same basic components but with a changed circuit and a new twin-electrode detection unit. In detecting the two common synergists, this new system ranged from 2,500 to 10,000 times as sensitive as the old machine. Tests with the organophosphates and carbamates were less spectacular, but even with these the new machine was 5 to 20 times as sensitive as the old one. Amounts of pesticides as low as 30 picograms could be detected (a picogram is one-millionth of a microgram which is one-millionth of a gram). Thus this new detector can measure amounts as small as about 1/33,000,000,000 or one thirty-three-billionth of a gram.

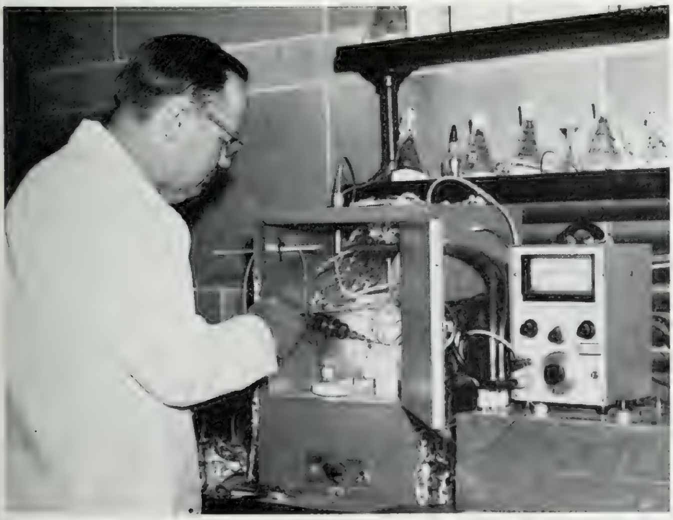
Dr. Bruce's new invention opens up tremendous possibilities in biochemical investigation where minute proportions of many classes of chemical compounds are involved, or those in which the sample subject is extremely small, such as a single small insect or a tiny bit of mouse tissue.

Hybrid Break-through

One of the ideals sought in fish management has been a situation in which plenty of small fish were produced, providing food for the predator species such as bass, yet enough small fish were removed from the water that they did not build up a population composed of an almost infinite number of small stunted fish. Various experimenters have tried a great assortment of combinations of different fish. The most successful have been some particular kind of sunfish plus bass, but almost invariably after two or more years the young sunfish became so abundant that they outran the food supply, resulting in a tremendous population of small, stunted fish. The bass apparently do not prefer sunfish for food; instead they select their own young, crayfish, and the larger aquatic insects.

One of the combinations tried out by Survey aquatic biologists W. F. Childers and G. W. Bennett has come remarkably close to the ideal. In early 1959, after removing all fish from it, they stocked a one-acre pond on the William Utterback farm near Gibson City with eight male red-ear sunfish and three female green sunfish. These two types crossed and during the summer produced a large number of hybrid young. In September Dr. Childers added 27 4-inch bass, in June, 1960, 250 1½-inch bass fry, and in August, 1960, 140 more bass averaging 6 inches. This was a total of 417 bass. In March, 1961, 13 small grass pickerel were added.

In 1960 the pond was opened to fishing; the fishermen kept a complete record of the time they spent fishing and the number and weight of fish caught. The catch from 1960 to 1965 was phenomenal. The



Dr. Bruce pointing out the critical elements in the new circuit he invented for the electron-capture machine. (Photo by Survey photographer Wilmer Zehr.)

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1960 start was slow, only 4 bass and 47 hybrid sunfish of legal length. In 1961 the bass catch jumped to 71, reached 134 in 1963 and 200 in 1965. Through 1964 the bass averaged about ¾ of a pound each, dropping in 1965 to about ⅖ of a pound. The original pure sunfish parents were never caught but the catch of hybrid sunfish jumped to 642 in 1961, 1,819 in 1962, dropped to 1,077 in 1963, then plummeted to 150 and 71 in 1964 and 1965. When the pond was poisoned and the remaining fish counted in September, 1965, it contained 742 bass of which 340 were over 6 inches, but only 29 sunfish hybrids, ranging from ¾ to 1¼ pounds each. The combined 1962 catch of 1,819 hybrid sunfish and 133 bass, weighing 324 and 93 pounds, respectively, constituted the highest per-acre yield (417 pounds) ever recorded in Illinois.

A good rate of catch (even to a fisherman) is one fish per man per hour, averaging in days when none is caught. For the Utterback pond the average catch of fish per man-hour of fishing was:

1960 — 1.5	1963 — 4.1
1961 — 2.9	1964 — 1.5
1962 — 6.2	1965 — 1.4

Dr. Bennett points out that the reason for the high rate of catch lies in the use of hybrids rather than pure strains of sunfish. The hybrids themselves bred and produced young, but it was apparent that the hybrid fry or very young individuals were extremely vulnerable to predation by the bass and did not build up a second generation hybrid population. Further, the large first generation hybrids are easier to catch than the pure species. Production of first-generation hybrids stopped when the pure red-ear males and green sunfish females died, probably in 1961 or 1962.

This experiment has two profitable results. First, it appears to have demonstrated a simple and easily managed stocking combination for farm ponds in this area, and, second, it opens up a whole new set of possibilities for further investigation and development centered around the use of hybrid mixtures.

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DECEMBER 1965, NO. 38

Double Trouble

Two sources of trouble for corn growers are increasing in Illinois. One is the northern corn rootworm, an old-time, state-wide inhabitant that is developing strains resistant to chlorinated hydrocarbons in ten northern Illinois counties. In Boone, McHenry, and McLean counties, only medium resistance has been noticed, but in Whiteside, Ogle, Lee, De Kalb, La Salle, Woodford, and Warren counties, highly resistant populations are present.

The other source of trouble is the western corn rootworm. After recently crossing our western boundary from Iowa, this rootworm is now established in Rock Island, Mercer, Henderson, Warren, Knox, and Hancock counties. In Mercer County the species has built up sizable populations but is still sparse in the others. Survey entomologists H. B. Petty and C. E. White believe that the western species will not produce economic numbers in Illinois for at least another year, except in a few fields in Mercer County.

The real worry about the western corn rootworm has been verified in resistance studies made on Mercer County populations by Survey entomologist R. E. Sechriest. He has found these to be highly resistant to chlorinated hydrocarbon insecticides.

Thus the spreading western corn rootworm and the spreading resistant races of the northern corn rootworm appear to be gradually blanketing northern Illinois with rootworm populations that cannot be controlled by present methods of treating soil insects with chlorinated hydrocarbons. These resistant types can be controlled with organophosphorus-type insecticides, but Dr. Sechriest points out that these are not very effective against wireworms, cutworms, and white grubs. As a result, future control of soil insects in Illinois cornfields may necessitate the use of both types of insecticide with a consequent doubling of control costs.

Preventive Medicine

In their battle against weeds, agriculturalists have developed several compounds

Left, the northern corn rootworm; *center*, female western corn rootworm; *right*, male western corn rootworm. Actual length is less than 1/4 inch. (Photo by Survey photographer Wilmer Zehr.)

that kill the weeds before they emerge from the ground. When applied to the soil, these pre-emergent herbicides either prevent the weed seeds from germinating or kill the young plant at a very early stage. Aquatic biologists are now trying to apply the same idea to the control of waterweeds that often ruin lakes and ponds for boating, swimming, and fishing.

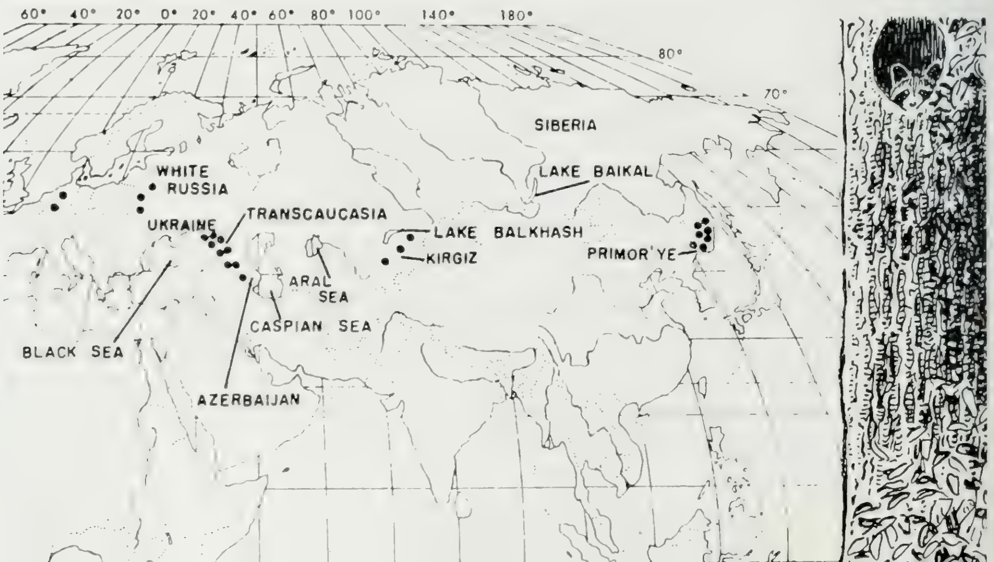
In 1962 Survey biochemist R. C. Hiltibran began applying some of these pre-emergent herbicides to Illinois ponds, but the compounds that had proved so successful in the terrestrial situation on the farm produced very poor results in the water. In 1964 two additional compounds, Fenac and dichlorobenil, gave promising results. Fenac was effective only when applied to the exposed bottom of the pond, whereas dichlorobenil was effective when applied to either the exposed bottom or through the water. Applied to the exposed bottom in late March, Fenac prevented the development of sago pondweed, reduced the stand of southern naiad, but had no effect on stonewort or chara. In the same conditions, dichlorobenil prevented the development of all three. Leafy pondweed is apparently a tougher customer, and control of this species has, to date, been erratic. This may be because sago pondweed normally produces all its growth early in the season, whereas leafy pondweed has spurts of growth later in the year.

Experiments in 1965 indicate that time of application may be very important. December applications may lose their effectiveness before the plants start to develop, and, depending on the season, April applications may be too late because the plants have already started vigorous growth.

The problem of the solubility of these compounds is still a puzzling factor that needs to be investigated. Although Fenac applied through the water appears to dissolve and diffuse away from the point of application, if it is applied to the exposed bottom and washed into the ground with a little rain, it appears to be held locally in the soil even after the area is reflooded. When applied under ideal conditions, both compounds are effective as pre-emergent herbicides for a year. With higher rates of application this period might be extended, but in this circumstance some unsolved problems are encountered as to how toxic these herbicides may be to fish, known to be harmed by concentrations above 20 parts per million of either compound. The unsolved question is: What rates of application and what conditions of the water will lead to dangerous amounts of herbicides in solution?

Dr. Hiltibran points out that the ability to control aquatic weeds before they become a nuisance would be especially helpful around swimming areas, boat docks, launching ramps, and certain areas trouble-

Basic distribution of the raccoon in the eastern hemisphere. The black dots indicate points where this tree-denning animal has been introduced and become established. (Inset of raccoon by former Survey mammalogist C. O. Mohr.)



some from the standpoint of mosquito control. He warns that there are still tricks to be learned and problems to be solved about pre-emergent herbicides before we will know the most effective methods of application and all the precautionary measures that should be observed. His experiments and observations planned for the coming year will seek to answer some of these questions.

Raccoon Coats for Russia

We hear a great deal about Eurasian animals introduced into North America – the house sparrow, European starling, ring-necked pheasant, Norway rat, to name only a few — yet we hear little about movement in the opposite direction, although many North American species have become established in the Old World. One of these is our well-known native raccoon. The story behind this establishment has recently been assembled in correspondence between Dr. Farman F. Allev, biological scientist of the Russian state of Azerbaijan, and Survey wildlife specialist G. C. Sanderson.

The start of this introduction was accidental. In the fall of 1929, a raccoon escaped from the Moscow Zoo and was recaptured the next March after wintering successfully in a neighboring forest. After this proof of its survival ability, the Russians decided to try introducing the raccoon into the wild.

In 1936, they released 22 raccoons in a walnut forest near Kirgiz, and at least 10 or 12 of these were still there the following year. They increased in numbers and dispersed 25 to 30 miles from the point of release.

From then through 1958, over 1,200 raccoons were released in widely scattered areas of Russia, from the vicinity of Moscow to Vladivostok. The first animals released were reared in zoos, but subsequently raccoons were live-trapped in various areas where they had become established and released in new areas. The 1964 estimated population of raccoons in Russia was forty to fifty thousand with an additional four to five thousand in East Germany.

The raccoons did so well that trade in raccoon furs began in 1954, but figures were not available as to the exact number that had been taken. It is certain that the raccoons have adapted very well to Russian conditions and have extended their range enormous distances from the release sites. They have become especially abundant in deciduous forests along rivers and irrigation canals, and in orchards. In 1951 their territory in Transcaucasia was drastically restricted by a severe summer drought. The raccoons migrated to high mountain forests where springs and streams were flowing, then at the onset of winter migrated back into the lowlands.

The future distribution of the raccoon in Eurasia is problematical, but it certainly seems to be well established in many parts of Russia that support orchards or deciduous woodlands.

Insidious Guests

When considering losses to agriculture, we are prone to notice and remember startling incidents, such as fields of grain completely destroyed by chinch bugs, the cherry crop ruined by weevils, or the tomatoes riddled by earworms. These and other sporadic outbreaks are only the conspicuous manifestations of a tremendous, little-noticed attrition exacted constantly from our agricultural efforts by a large number of insects and plant diseases.

Plant diseases are especially insidious because most of them grow unseen within the plant and only in the later stages of their life history does their presence show up as low yield, shrunken fruits or kernels, rotted fruit, or dead plants.

In order to replace hazy guesses with reliable estimates, in 1930 Survey plant pathologist G. H. Boewe began an accounting of losses caused to Illinois agriculture by plant diseases. Every year, for 33 years, he examined tree fruits, small fruits, vegetable crops, field crops, and pastures in different parts of Illinois, determining for each crop the prevalence of various diseases and the damage they were doing. This required correlating collecting with known times of appearance of disease

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symptoms and a knowledge of the different kinds of diseases encountered.

Identifying the different kinds of diseases proved to be no mean task. In his travels up and down the state, Mr. Boewe encountered 776 different kinds of fungus, bacterial, and virus diseases. Seventy-five had never before been reported from Illinois and 15 of them had never before been found anywhere. To complicate matters, in well over one hundred instances, fungi were found attacking previously unrecorded hosts, often producing different symptoms from on the old hosts and thus rendering identification difficult. Many disease samples were collected also from native or noneconomic species of plants to check on possible reservoir host species that might be sources of infection. Samples from these activities constitute the backbone of the Survey's collection of over 34,000 preserved samples of plant disease organisms.

Using conservative estimates, Mr. Boewe's figures indicate that Illinois farmers sustain an annual loss of about 200 million dollars from plant diseases. Fully half of this is caused by plant diseases of corn, which reduce the potential corn yield by about 100 million bushels per year. Diseases of wheat cause an estimated yield reduction of about 10 million bushels per year, with a dollar value about double that figure. For each crop, the losses represent the sum total of yield reduction caused by as many as twenty or thirty different kinds of disease organisms. Often each kind attacks different parts of the plant and causes damage in a different way. For many crops this diversity of attack makes economical control measures extremely difficult.

Plant pathologist Boewe is now analyzing the tremendous amount of information gathered in his 33 years' survey in an effort to determine the role of weather, cultivating methods, crop rotation, and other factors on the occurrence and abundance of the different plant diseases. There may be in these figures some hints whereby extensive savings could be made through the manipulation of crop rotation or changes in farm practices.

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JANUARY 1966, NO. 39

Corn in the Crib

In storing ear corn on the farm during the warmer months farmers in the southern third of Illinois face an insect hazard that is seldom a factor to the north. This troublesome insect is called the Angoumois grain moth. The adult moths, less than a third of an inch long, crawl through stored corn and lay eggs on the kernels. Each egg hatches into a minute larva that burrows into a kernel where it grows up and transforms first into a pupa, then into the adult moth. The adult leaves the corn kernel and starts the cycle again. A small round hole is visible on the kernel where a moth emerges. Stored shelled corn is seldom bothered by this moth, because the fragile moth cannot force its way between the closely packed kernels in the bin and hence can attack only the kernels on the surface. Ear corn, however, has spaces between the ears that the moth can follow throughout the entire crib.

The moth is essentially a southern species, and the winters of the northern two-thirds of Illinois are too rigorous for it to become established. In the southern third of the state it is usually abundant and active from about April into the fall. If ear corn is stored only until April or May, it is in no danger from this particular pest, but if it is held through the summer months it stands a good chance of becoming heavily infested. This often happens when the farmer has received a purchase-agreement loan with the Federal government, which may not claim the corn until late June or July. The farmer may dis-

Hand equipment shown here is effective for applying insecticide sprays to corn in the crib.

cover that by this time the grain moth has done sufficient damage to reduce the quality of his corn from one to several grades, and he may lose anywhere from 10 to 50 cents a bushel when he delivers the corn.

Survey entomologists Steve Moore, H. B. Petty, and J. H. Byers have recently made intensive studies of the occurrence of and damage caused by this little moth in ear corn held on the farm in crib storage. They found that one or more insects occurred in a kernel, and that each individual insect ate about one-tenth by weight of a kernel of corn. The average loss of corn by weight for the entire crib ranged between 1 and 2 per cent. Nearly a third of this occurred in the outer 18 inches of the ear corn in the crib, decreasing to only slight losses in the center.

Convenient, effective, and inexpensive full season control of the Angoumois grain moth was the next goal of the entomologists. They found that a single spray or dust treatment of premium grade malathion gave this desired result and had the added advantage of being effective against other kinds of stored grain insect pests that are invariably present also in stored corn. Details of exact materials and methods to be used in these treatments can be obtained by writing to the Survey.

Lettuce *Is* Rabbit Food

When studies of changes in habitat type indicated a positive statistical correlation between rabbits and leafy herbs (*see* "Food and Shelter" in *Reports,* No. 36), Survey wildlife biologists J. A. Bailey and R. J. Siglin set up exploratory feeding trials with young cottontail rabbits. Rabbits 3 to 8 weeks old, ranging from 3 to 15 ounces, were confined in cages provided with water and a salt block, and those in each cage were fed only one species of food. Check animals were given no food. The tests were run for 14 days.

Of the six species of plants tested, only prickly lettuce and chicory produced sustained growth of rabbits. Plantain produced good growth in some animals, poor growth in others, and is therefore a question mark from the standpoint of rabbit nutrition. Red clover and smartweed did not sustain rabbit weights, and their nutritional value is questionable.

Bluegrass, previously considered an important rabbit food, was the poorest of all the plants tested. As a matter of fact, rabbits fed bluegrass exclusively survived only 1 or 2 days, no longer than the rabbits without food. Thus at least in midsummer (when these experiments were made), young rabbits can digest bluegrass only in minute quantities or not at all.

These results support to a remarkable degree the results obtained from previous studies of rabbit habitat. Prickly lettuce and chicory, plus closely related plants such as fleabane and aster that may also be nutritious rabbit foods, are among the first plants to become established on cultivated land turned back to the wild. This leafy vegetation not only offers rabbits good cover, but is highly nutritious. Under natural conditions, this leafy-herb vegetation is gradually replaced by perennial grasses, frequently bluegrass. The observed decline of rabbit populations in solid bluegrass stands is now seen as a natural consequence of both decreased cover and a reduction in digestible food.

Alpine Currant Anthracnose

When Survey plant pathologist D. F. Schoeneweiss was developing the spray program so effective in controlling anthracnose of Alpine currant, he noticed that the disease symptoms of Alpine currant were different from those produced on gooseberries and fruit currants. On Alpine currant, the fruiting bodies of the anthracnose appeared almost exclusively on the lower leaf surface, whereas on gooseberries and fruit currants these fruiting bodies or lesions were produced on the upper surface of leaves, and on the leaf stems. The size of the individual spores were also different in the two categories. These differences in symptoms and spore size raised the question: Were they due to the effect of the same disease reacting differently in different kinds of host plants, or was the disease on Alpine currant different from that on gooseberries and fruit currants?

Twigs of Alpine currant showing the yellowed leaves caused by anthracnose. The dark spots on these leaves are the spore-producing fruiting bodies of the anthracnose fungus.

To test this, Dr. Schoeneweiss injected various hosts with spores taken from other hosts. The spores are produced in a waxy mass on the little black spots or lesions that are the fruiting bodies of the fungus. These spores were removed with a sterile needle and shaken in distilled water to make a suspension which was sprayed on leaves of rooted cuttings. The cuttings were then incubated for about two days at 65 to 70 degrees, then kept at room temperature. If the disease "took," spore lesions appeared in about eight days. Diseased leaves turned yellow within two weeks and frequently dropped off soon after.

None of the Alpine currant suspensions produced disease symptoms on gooseberries and fruit currants, and the spore suspensions from the latter plants did not infect Alpine currant. It is therefore obvious that the Alpine currant anthracnose is a separate strain or species that in Illinois occurs only on this one host. Dr. Schoeneweiss' discovery means that if anthracnose is found on gooseberries and fruit currants, there is no danger of its spreading to Alpine currant, and vice versa.

Triple Use Tilapia

When Survey aquatic biologists obtained a colony of the vegetarian African fishes called tilapias or mouth-breeders (so called because they carry their eggs and very small young in their mouths), no one knew just what the role of these fishes would be in Midwestern waters. The fish can tolerate water temperatures no lower than 50 degrees (they are really tropical), and hence here must be kept indoors during the winter. During warm weather these fish eat vegetation voraciously and grow rapidly. On their great appetite rests their reputation that they can control aquatic vegetation with remarkable efficiency.

Because the tilapias are so efficient in controlling both excessive algae and rooted vegetation, they tend to produce a clear clean pond ideal for bass and sunfish. In 1963 aquatic biologists G. W. Bennett and W. F. Childers began running pilot tests to see what would happen when tilapias were combined with different combinations of our native game fish. These tests were run in 2½-acre Arrowhead Pond situated in Robert Allerton Park near Monticello. In April and May of 1963, the lake was stocked with 124 good-sized bass and 58 tilapias per acre. One-fifth of the bass were breeding adults. In the fall the pond contained nearly a thousand bass but only 11 tilapias per acre. The pond was so overgrown with aquatic vegetation that fishing was almost impossible. The tilapias recovered in the fall were unquestionably some of the larger ones with which the pond was originally stocked; apparently the bass had eaten all the young tilapias as fast as they were produced.

In 1964, another combination was tried. Again the pond was stocked in May with 50 tilapias and in July with 126 bass per acre, but the bass were only an inch long. By fall the pond contained 164 tilapias and 91 bass per acre, the latter averaging half a pound. Vegetation control was moderate. The production of fish in terms of pounds per acre was high. Because all stocking was done with small fish, the pond started out with only a pound of tilapia and a tenth-pound of bass per acre, ending with 16 pounds of tilapia and 43 pounds of bass per acre.

In 1965, the pond was stocked with 50 tilapias but only 58 bass per acre. Again the tilapias were put in the pond in May and the bass were added in July. In the fall the whole pond contained about

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20,000 tilapias, weighing a combined 1,200 pounds, and 100 bass totaling 57 pounds. Vegetation control was almost perfect. Although the per-acre poundage of bass rose only from one-tenth of a pound per acre to 22 pounds per acre, the individual fish averaged six-tenths of a pound.

These experiments point out the feasibility of combining tilapias with bass in our local sport fisheries economy. The tilapias serve three purposes:

- If given a head start so that they can build up a sizable population, they control aquatic vegetation and produce a clean pond satisfactory for fishing.
- Their abundant young, produced all summer, furnish excellent bass food.
- They provide good fishing in their own right. The larger tilapias put up a better tussle than a sunfish and are good eating.

Their use does demand keeping a colony indoors over winter but this is not difficult. Dr. Childers is quick to point out that this necessity is really a blessing in disguise, because the tilapias in the pond die with the onset of winter and there is no carry-over of thousands of little fish into the next season. This die-off effectively avoids the build-up of immense populations of stunted fish, the bane of fish management. Dr. Childers also points out that we need to know how tilapias will work out with other kinds of sport fish, and he is planning to test them with combinations of bass and sunfish during the coming year.

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FEBRUARY 1966, NO. 40

Face Fly Decline

After the face fly first became established in Illinois in 1959, it quickly soared to abundant and injurious numbers through 1962 and 1963. Then in 1964 and 1965 its numbers dropped off very appreciably. The reason was, and is, quite a mystery. Although farmers had been treating dairy cows with a poison bait that was effective against flies on the animal, this sort of treatment normally does not appreciably decrease general field populations. Was the decrease due to adverse weather conditions or to parasites or predators that were attacking the immature stages? If it was the latter, these might provide a means of keeping face fly populations below economic levels without the constant use of insecticides. With these thoughts in mind, Survey entomologist R. D. Pausch began a survey of face fly parasites.

Adult of the face fly, about ⅕ inch long. (Photo by Survey photographer Wilmer Zehr.)

Cattle droppings are normally a regular beehive of insect activity. A few kinds of flies lay eggs on a dropping almost as soon as it is deposited, the eggs hatch within minutes or hours, and the larvae feed and grow very rapidly in the fresh cake. Other kinds of flies, then later certain kinds of beetles, feed in the cake, until finally all but a shell is consumed as insect food.

The face fly is one of the early birds in this succession of cattle dung insects. Together with the horn fly, another irritating species, the face fly deposits eggs in the cake almost the minute it is dropped. The eggs hatch and the maggots mature in 4 or 5 days, then crawl away from the droppings, burrow down into the soil, and transform into the resting stage or puparium. In another 7 days the adult fly emerges from the puparium and begins the cycle all over again.

To check on breeding numbers of face flies, Dr. Pausch selected seven collecting sites scattered from Rockford to Vienna and Champaign to Carthage, thus sampling face fly populations in different parts of Illinois. Every two weeks 10 droppings were collected separately from each site, taken to the Urbana laboratory, and placed in rearing containers having a layer of sand in the bottom. The face fly larvae completed their development in the droppings and pupated in the sand. The pupae were screened from the sand and individual pupae put in gelatin capsules where any parasites would emerge and be captured. Many of these parasites are such

tiny things they will go through even very fine wire screen with no trouble.

The face fly proved to be present in fantastically low numbers. Out of 940 cakes sampled a total of only 75 face flies were found. This averages out to only about 1 fly to every 12 cakes. Although parasites have been reared from face flies in other parts of the U.S., none emerged from these samples, giving some indication that the Illinois face fly decline was not caused by parasites. The summer was on the wet side, and rain is known to affect adversely insects such as the face fly whose larvae breed in the very fresh cakes. It hardly seems possible that these adverse conditions would have occurred throughout the entire state for 2 years.

Could it be that the years 1960 to 1963 had weather unusually favorable to the face fly, and that the face fly can exist in Illinois only under these unusually favorable conditions? If so, in most years the face fly may not be of any economic importance. But it is yet far too early to make reliable judgments, and Dr. Pausch is planning to keep a sharp eye on face fly populations this coming year.

Brain Weight and Age

One of the most difficult problems associated with understanding the make-up of bird populations and figuring out details of their life histories is the problem of determining how old each bird is. In long-lived birds such as geese and gulls, the young birds have differences in plumage following each molt for one or two years, and these plumage differences allow accurate aging of at least the younger birds. For smaller birds such as thrushes and warblers, there are fewer of these landmarks and aging is more difficult.

It had been known for some time that brain weights in birds decreased after the fledglings left the nest. A few years ago Survey ornithologists R. R. Graber and Jean W. Graber found that these weight changes appeared to stretch even farther into the life history, because in passerine birds the immature migrants, long off the nest, still had heavier brains than adult migrants. Here seemed to be a possibility for getting another measure of the elusive age determinations of birds. When kills of migrant birds at television towers made available several hundred nocturnal migrants of many bird species, the Grabers and their Survey colleagues gathered the birds while they were still fresh, weighed them and put them in the deep freeze, then later studied the weights of the brains.

The chemical analysis of these brains, combined with certain critical work on a few species done primarily by German investigators, indicates that the pattern of brain changes in nestling birds is in general like that of many mammals, and different from that in the precocious birds like sandpipers and ducks whose young are active and independent when hatched. In newly-hatched birds, the weight of the brain increases very rapidly, first by the addition of large amounts of water, followed by a pronounced increase in protein and fat. After the bird becomes mature the brain weight decreases, chiefly through a loss of water.

After the brain of the early adult loses weight through loss of water, the proportion of fats to water increases greatly. But the Grabers discovered that in the mature birds the *actual weight* of fats was slightly lower in the adult birds than in the immature migrants. These measurements suggest a possibility that the actual fat content of the brain in these birds decreases at possibly a slow rate beyond the time when other commonly used marks of age disappear. If the brain does lose weight throughout the life of the individual, then brain weights may be useful in extending our ability to age wild-caught birds.

A New Sycamore Disease

In 1961, Mr. Grover J. Norwood, science teacher at the local high school, called our attention to serious losses of sycamores in the streets of Granite City. Investigating the problem, Survey plant pathologists E. B. Himelick and Dan Neely discovered the death of the sycamores was preceded by symptoms answering no known disease of the species. First symp-

One of the sampling nets showing the top of its 1-foot square opening and the poles by which it is held in place in the river. At each station one net was placed near the bottom of the stream, a second at the top and just protruding, in order to catch anything floating on the surface. (Photo by Paul Fishman.)

toms are a scorching of the foliage in upper branches or over the entire top of the tree, followed by the appearance of long cankered areas on the upper branches extending back to the trunk. Subsequently these cankers extend down the trunk to the ground. Trees die two or three years after the scorching first appears.

At first smoke damage was blamed, but the canker production soon suggested that a parasitic fungus was the cause of the disease. Smoke as a factor was definitely eliminated when surveys showed that the disease occurs along the Mississippi from Chester to Granite City, along the Wabash from Shawneetown to Mt. Carmel, and in occasional towns through the central part of the state. Isolation tests of diseased trees have now narrowed down the search for the causative fungus to two suspects, and tests this coming year should definitely establish which of these is the primary cause of the disease.

Dr. Himelick has evidence suggesting that the disease occurs also in Kentucky and Missouri. He points out that it is primarily a disease of American sycamores and that London plane trees, a very close relative, are seldom attacked and seem to be less susceptible to the fungus. Because sycamores have been planted so profusely in Illinois following the death of elms, this new sycamore disease could be quite destructive to city plantings. Dr. Himelick and Dr. Neely are watching its spread closely and trying to find how the disease invades healthy trees.

Nocturnal Highway

Because they lack the glamour of the clearer bass, pike, and trout waters, the turbid medium-sized rivers of the Midwest have not been fully appreciated as recreational assets. This picture is now changing. Impoundments on many of our rivers will produce chains of lakes along the streams and provide new values in water recreation. The added available water supply will undoubtedly increase industry and enlarge the towns along the banks of the rivers and their tributaries. Such a river is our Kaskaskia.

In trying to foresee the future uses of these waters, many difficulties loom up. We don't know what effect the alternating river and lake conditions will have on the life in ~~the~~ water, especially that forming the basic bulk of the fish food, nor do we know what will be the effect of the predictable increase in both industrial and sanitary pollution as the resident population increases.

In attempting to formulate some plan of action to document these changes, Survey aquatic biologists have studied the fishes of this river for many years and now realize that we are faced with another difficulty. These medium-sized and turbid rivers have never been studied limnologically, so that we lack sufficient knowledge concerning present conditions to be able to measure changes in the future. It was therefore considered high time that a thoroughgoing scientific investigation of a turbid, medium-sized river be started, and the Kaskaskia was chosen as a good repre-

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sentative stream. Accordingly, last July five observation stations were established at intervals between Sullivan and a point south of the Carlyle dam. Primary objectives were to discover the source and type of fish food in the system, and to discover what effect water level, impoundment, dredging, and pollution had on the food supply.

Preliminary surveys made by Dr. R. W. Larimore and his assistant, Paul Fishman, indicated that much of the potential fish food was in the form of different kinds of insects and minute crustaceans (relatives of crabs and lobsters). Preliminary sampling of the river itself indicated that much of the river bottom produces very little fish food. When net traps were put in the water in these areas, however, it was discovered that the water itself often teemed with aquatic organisms apparently drifting with the current. Irregularities in these occasions, however, indicated the desirability of taking samples hourly around the clock and regularly throughout the year.

The around-the-clock samples provided a real surprise. The river water contained relatively few drift organisms during the day, but as soon as night fell the quantity of living things in the water shot up to a tremendous peak and stayed there until the next dawn. A great proportion of this nocturnal drift is comprised of insect larvae that had been thought to be almost completely sedentary, such as caddisfly larvae and midge larvae. For reasons not yet understood, large numbers of these normally hidden forms leave their retreats at night and drift down the river with the current. Dr. Larimore points out that this explains some of the feeding habits of certain fish that increase their activity as darkness approaches. He points out also that this daily rhythm of activity gives us a new perspective on available fish food, and will require entirely new methods of sampling and assessing aquatic organisms in flowing streams.

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Dainty but Damaging

Several Illinois florists were concerned this year when the leaves of their potted azaleas started shriveling and turning brown, giving the plants a very disagreeable appearance. At first the damage was thought to be leaf burn resulting from chemical applications. When Survey entomologists W. E. LaBerge and J. E. Appleby examined the damaged leaves more closely, they found small light green larvae mining in the leaves. The pest proved to be the azalea leaf miner. As is true of many insects, its technical name (*Gracillaria azaleella*) is much longer than the insect 3/16 of an inch). The adults are small, dark, gray-brown and yellow moths having remarkably brilliant metallic reflections. They generally frequent the underside of the leaves and are seen flying only when the plant is disturbed.

The female moths deposit eggs on the azalea leaves. After hatching, the larvae crawl over the leaf surface and soon enter a leaf and begin mining. After mining inside the leaf, the larvae leave the interior of the leaf and crawl to the leaf surface and feed. Soon thereafter they fold over the leaf tip or margin and construct a small white web on the underside of the leaf where pupation occurs. After pupation the moths emerge and the life cycle is repeated.

In watching for this insect, Dr. Appleby recommends observing the plants for leaf damage early in their forcing period, and points out that the small webs can be easily observed if the entire plant is tilted to one side. He recommends two spray applications of malathion or diazinon at an interval of 12 days. This treatment should kill all the moths before they have an opportunity to reinfest the plant.

Like many of our other pests, this handsome little leaf miner is not a native. Dr. LaBerge points out that it was introduced into this country from Japan through Holland early in the century and has appeared

Above, moth of azalea leaf miner in characteristic pose; *below*, weblike cocoon spun under a leaf by the larva and, just showing in the upper left of the picture, a shriveled leaf caused by larval feeding. Length of moth 3/16 in. (Photos by Survey photographer Wilmer Zehr.)

sporadically in the eastern states as far west as Ohio. This is only the second year that this little leaf miner has been noticed in Illinois.

Dutch Elm Disease

Because of their tremendous investment in park and parkway trees, the municipalities and park districts in the greater Chicago area continue the fight against Dutch elm disease, the major shade-tree problem in Illinois. Basic control procedure in these communities consists of three phases: (1) sanitation, which is the prompt removal and destruction of all infected or dying elms; (2) spraying healthy elms with a fall or spring dormant spray; and (3) if the trees are close together, using soil sterilants to prevent transmission of the disease through grafted roots. Through these methods, approximately 40 greater Chicago municipalities have kept their losses for the last 10-year period to a low 3 to 8 percent of the original elm population.

Every year Survey plant pathologist Dan Neely obtains a report on the control program and elm losses from the forester, city manager, or director of public works of each municipality or park district. Of 27 having both complete sanitation and a spray program for all public trees, losses were very slightly higher in 1965 than in 1964. In 1965 ten cities had disease losses of less than 1 percent, 12 had losses between 1 and 2 percent, and 5 had losses between 2 and 2½ percent. Municipalities in the greater Chicago area with incomplete or no control programs suffered losses in 1965 from 7 to 10 percent of the original elm population. In some nearby municipalities losses were even higher. The slight increase of losses in the treated areas is probably due to a general increase of elm bark beetle populations in areas without control programs. From these results, Dr. Neely feels that sanitation and spraying control practices, although far from ideal, are effective if vigorously and thoroughly utilized.

Because it is less toxic to wildlife, 7 municipalities have switched to methoxychlor instead of DDT as a spring dormant spray. In these the control has averaged as satisfactory as in municipalities still using DDT.

The Insects' Cut

When early in the year most people are sharpening their pencils to figure out their income tax, Survey entomologists are tabulating data from farmers, extension staff, county agents, and their own files to figure out how much insects have cost Illinois farmers. Entomologist C. E. White estimates a total 1965 insect bill for field crops of 43 million dollars ($117,000 per day). This includes the cost of insect control measures amounting to over $17 million, replanting costs of nearly $3 million, and losses in yield of over $23 million.

Looking at the other side of the coin, his colleagues H. B. Petty, Stevenson Moore III, and Roscoe Randell have been gathering figures on the results of the control treatments. In 1965 insecticides were applied to about 5,600,000 acres, saving crops

Acres of Field Crops Treated with Insecticides and Estimated Profit from Treatment, Illinois, 1965

Crop and Insect	*Acres Treated*	*Estimated Profits**
Clover and Alfalfa		
Potato leafhopper	18,500	$ 37,000
Meadow spittlebug	910	1,365
Pea aphid	10,640	21,280
Clover leaf weevil	4,123	6,185
Variegated cutworm	2,353	4,118
Sweet clover weevil	2,143	17,144
Corn		
Soil insects	4,733,784	23,668,920
Cutworm	411,633	2,469,798
Chinch bug	69,139	414,834
Fall armyworm	21,651	21,651
European corn borer	83,507	292,275
Corn leaf aphid	55,333	110,666
Corn flea beetle	35,951	179,755
General		
True armyworm	75,346	264,594
Grasshoppers	64,570	149,896
1965 Total	5,589,583	$27,659,481
1964 Total	5,202,480	$18,775,550

* Over and above treatment costs.

Migrating robins in an Illinois woodland. (Photo by Dr. Graber.)

valued at over $27,500,000. From the standpoint of insect pests, 1965 was a much tougher year than 1964, during which only 5,200,000 acres were treated, with a crop saving of nearly $19,000,000 after treatment costs.

Focusing Fish Facts

Last February 14, fisheries investigators converged on the Shedd Aquarium in Chicago to attend the Fourth Annual Meeting of the Illinois Chapter of the American Fisheries Society. In 1962, fish people in the state felt that much would be accomplished toward improving fish management and coordinating fish studies if at least once a year there could be practically a free-for-all discussion in which research findings and fish-management problems could be compared and integrated, with special reference to the particular conditions and problems occurring within the state of Illinois.

The result of this movement was the organization of an Illinois Chapter of the American Fisheries Society, holding its first meeting in Carbondale in 1963. The meetings of the Illinois Chapter, usually held every February, have been great successes. They have provided a regular interchange of information and progress reports by the fisheries workers from the length and breadth of the state in which findings on ecology and systematics have been made available for application to fish management, and problems of management have led to insights concerning research questions still unanswered.

When Chapter President Leo F. Rock, Illinois State Department of Conservation, banged the opening gavel last February 14, he opened a three-day session attended by over 50 of the top fish people in Illinois and set in motion a program of 16 technical reports, 2 symposia, and a great deal of discussion. If you were unable to locate the Survey's fish men at Urbana at this time, it was because all but one were at the Chicago fish meeting.

When the North Wind Doth Blow

One wonders how many moist eyes have been caused by this sad little line about the robins in the snow. As a matter of fact, the story does not apply to this country but to England, where the English robin (a bird much smaller than ours) does actually reside through the winter. But it is a cute little poem still appearing in American schoolbooks and softening little hearts toward the robins in the back yard.

If they are really caught in the snow, most of our robins have to suffer through only the light snowfalls of more southern areas, where they overwinter. Robins over most of the continent seem to move south in waves, the southern groups moving first, followed gradually by the more northern populations. A few populations overwinter as far north as Wisconsin, but by onset of winter most of them have taken up residence from southern Illinois to the Gulf states. The robin you saw along a southern roadside on your Florida Christmas vacation may have been the robin that nested in your back yard last summer.

There is a curious difference in the way robins behave when nesting in the back yard as compared with their southern winter sojourn. In summer they are trusting creatures that will almost land on your hat, pick up worms only a few feet behind you in the garden, or bathe in the stream

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of water coming from the hose in your hand. When migrating they seem to avoid humans and spend most of their time in the woods away from dwellings. Survey wildlife specialists F. C. Bellrose and R. R. Graber point out that the late-season woodland robins in Illinois are not our own local residents on the wing south but are the larger, darker northwoods race migrating through Illinois after our summer residents have left.

These migrating robins are highly social and congregate in large numbers for the night. Wildlifer Bellrose discovered a robin roost of unusual proportions last October near the confluence of the Spoon and Illinois rivers, opposite Havana, Illinois. On the morning of October 12, he and his assistants observed hundreds of robins migrating past the Survey's field laboratory five miles north of Havana, and traced the spectacular flight west across the river valley to the vicinity of Dixon Mounds State Park. That evening flocks of robins were observed leaving the bluffs along the Spoon and Illinois rivers and flying east across the bottomlands of the valley. Flock after flock came to rest in groves of soft maple trees, some four miles away, on the banks of the Illinois River. That night the roost contained at least 9,000 birds.

A steady stream of migrating robins continued to pass the Survey's field laboratory almost every morning through the remainder of October. The numbers of robins in the roost continued upward to a peak of 22,500 on October 23.

There was a large departure the night of October 23, for only 9,400 were found on the 24th. However, several hundred robins continued to use the roost to mid-November.

Small roosts of robins are known to occur throughout the year. Male robins will even congregate in roosts during the nesting season. However, large roosts of robins have been reported only from their wintering grounds. One such roost in Arkansas was estimated to contain 250,000 robins.

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Inside Story

Last summer did the leaves of your pet iris get watery and slimy? Did their rhizomes get hollowed out and finally shrivel up? This would have been the work of the iris borer, the larva of a nondescript brown moth. The larvae hatch from the eggs in late April, crawl to the new iris foliage, and tunnel into them. They mine the leaves for a short time, then move to the back of the leaf sheath and feed on developing flower buds and stems. As the season progresses the larvae move downward through the plant and feed inside the rhizomes. If an infested iris clump consists of only two or three rhizomes, borers may destroy the entire clump. They show a great propensity for feeding on the choicest and best-tended iris varieties.

By mid-September the larvae are full-grown and leave the rhizome, pupating in the soil. The adult moths emerge in late September to mid-October, mate, and deposit the overwintering eggs in folds of the iris foliage. The next spring, larvae hatching from these eggs leave the dead shriveled leaves and seek the tender growth of the new year.

To date the only satisfactory control has been to spray the foliage with DDT at five-day intervals in late April through mid-May. In hopes of finding a chemical that would give control with one application, Survey entomologist J. E. Appleby experimented with systemic insecticides. These are compounds that penetrate to the inside tissues of the plant and are transported to various parts of the plant. One organophosphorus compound called dimethoate 2E showed considerable promise, but in early season experiments a serious difficulty arose: the dimethoate killed the borers but it ruined the plants. Their stems were weakened so that the blossoms bent over and almost touched the ground. Other iris sprayed later in the season when the plants were hardened and in full bloom showed no damage and the borer was controlled in good fashion.

Dr. Appleby points out that these preliminary results cannot be used as a broad-basis recommendation because different

Caterpillar of iris borer in iris rhizome. The larva attains a length of 1½ inches. (Photo by Dr. Appleby.)

varieties of iris, of which there are hundreds, may react differently to dimethoate. This summer he is going to test these reactions. But he is on the track of something that could be a real boon to the thousands of Illinois iris lovers and which, because of dimethoate's shorter residual activity compared with that of DDT, may reduce the year-round insecticide hazard to juncos, cardinals, sparrows, and other ground-foraging birds of the garden.

Bidrin

Although effective to a remarkable degree if followed thoroughly, present methods of controlling Dutch elm disease, the scourge of American elms, have a number of disadvantages. Tree pathologists have sought and are still seeking some compound that can be injected into an elm tree and make it immune to attack from either the fungus that causes the disease or the little bark beetles that carry the disease organism from infected to healthy trees.

In early tests of these systemic compounds, one called Bidrin showed some promise, and in 1959 Survey entomologist L. L. English and plant pathologist Walter Hartstirn ran a series of experiments to test its efficiency. They found that under their conditions of use, dosages of Bidrin sufficient to afford some protection against the bark beetles unfortunately injured or killed many of the trees.

Some workers in other states reported more favorable results whereas other workers reached the same conclusions as Dr. English and Dr. Hartstirn. In an effort to resolve this problem, the United States Department of Agriculture conducted large-scale experiments in 1965 in Cleveland and Toledo, Ohio, Wayne County, Michigan, and Moline, Illinois. Beforehand, plans of the experiments were circulated for criticism of scientific design to practically all pathologists and entomologists in the eastern United States who were engaged in serious research on Dutch elm disease.

The results of these tests have recently been tabulated and released by Dr. R. R. Whitten of the USDA. In the grand total, 977 trees were treated with Bidrin according to the directions supplied by the manufacturer; of these 294, or 30 percent, became affected with Dutch elm disease. The 980 carefully observed check trees received no treatment; of these 234, or 24 percent, became affected with Dutch elm disease. The percentages were remarkably close in each of the four test areas. It is obvious that in these tests Bidrin did not provide any protection against infection by Dutch elm disease.

Experiments carried out in the Northeast during 1965 and recently reported at the Shade Tree Laboratory of the University of Massachusetts tally remarkably with those obtained in the Midwest. The combined 1965 USDA and Northeastern tests indicate that the search must still continue for a systemic treatment that will be effective in suppressing Dutch elm disease.

Hikers Take Warning

Although several hundred ectoparasites feed on Illinois birds, reptiles, and mammals, less than a dozen kinds attack man. Two of these, the wood tick and the common chigger, will soon be abundant again.

In southern Illinois the wood tick begins its activity in late February, in the north in May, becoming numerous in April, May, and June. The female ticks secure a blood meal from a mammal, lay their eggs and die. Usually they are all gone by late July. Survey entomologist L. J. Stannard points out that although the wood tick inflicts little pain, if infected, it can transmit the virus that produces spotted fever, which can be fatal. Every year a few cases are reported in Illinois (nine last year), most of them undoubtedly transmitted by the wood tick.

Persons going out of doors, especially in brushy and wooded areas in the southern half of the state, should check themselves for ticks as soon as possible after exposure. Any found attached to clothing or the body should be removed and destroyed. Ticks may wander on a person several hours before finding a suitable spot for feeding. A favorite one is at the base of the head at the hair line. According to Dr. N. J. Rose, Illinois Department of

Dr. Hanson showing Dr. Jones the primary feathers on a Canada goose wing sampled for mineral analysis. (Photo by Survey photographer Wilmer Zehr.)

Public Health, Springfield, your doctor can now treat spotted fever with oral doses of antibiotics.

Chiggers appear later on the scene, mid-May in southern Illinois, early June in the north, continuing until at least September. As with the wood ticks, chiggers are more common in brushy places in central and southern Illinois. Here they transmit no disease organisms to humans but their bite causes painful itching. Because they are much smaller than the head of a pin, they cannot be detected and removed. As preventive measures, Survey entomologist W. N. Bruce recommends a solution containing one part benzol benzoate in nine parts of light mineral oil, rubbed on the feet and legs, under the belt line, and around the groin each day before going into the fields or woods.

Feather Detectives

As he discovers more and more strains or races of North America's largest game bird, Survey wildlife specialist H. C. Hanson points out that what we have called the "Canada goose" is really the "Canada gooses." A dozen races are currently described, with probably four more to be diagnosed. For some, including the race comprising most geese overwintering in Illinois, we have excellent data on their seasonal activities and the extent of their breeding area. For many races this information is quite meager because they nest in areas of northern Canada where it is difficult and expensive for ornithologists to penetrate and band significant numbers of birds.

Until now banding birds on either the summer or winter range and recovering them on the other range has been the chief way of getting information concerning the many questions arising from the recognition of Canada goose races. However, unless the race of the geese banded is accurately known, the information gained from band recoveries has limited value. Dr. Hanson now has an exciting new lead that may open the door to tremendous amounts of new information.

Several years ago an ornithologist found that grouse in a New England state could be associated with a particular geographic area by the mineral elements deposited in their feathers. Areas of the state having different geological histories had different combinations of mineral elements in their

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soils, and these soil differences were mirrored in the chemical composition of the feathers. Dr. Hanson thought this might be a real aid in studying the distribution of waterfowl populations and he enlisted the collaboration of Dr. R. L. Jones, soil mineralogist of the College of Agriculture, University of Illinois.

Using the outer three-quarters of the primary feathers as samples, the two checked the mineral content of Canada goose samples representing different races from different areas. Many notable differences were found in the amounts of various minerals in the feathers of the different races. The minerals currently being assayed are zinc, boron, iron, manganese, magnesium, cobalt, sodium, aluminum, copper, silicon, molybdenum, and phosphorus. In an early test, feathers of the Great Basin race of Canada goose were found to have a low zinc content: it was subsequently learned that this area is deficient in zinc. In another test, a completely unique specimen of Canada goose (undoubtedly a heretofore unknown race) collected in northwest Missouri had a feather mineral profile unlike that of any other goose so far studied. Here is an odd goose that must be nesting in an area with a distinctive soil type; it is only a matter of time until the breeding area of this undescribed race will be tracked down.

Busy working out mineral-feather profiles for various races of Canada geese, Dr. Hanson and Dr. Jones point out that they have a good start on the vast collection of wing feathers on hand, assembled in large measure as a result of many diligent cooperators across the continent. Dr. Hanson feels that this is a tool that will be a reliable check on the distinctness of the various races of geese, will give us added insight concerning their complete breeding ranges, and may indicate the existence of as yet undiscovered breeding areas for some of the commoner races. It is also certain to answer questions concerning the mixing of races on the various wintering grounds. The final objective, of course, of this and other basic research is to learn enough about the races of Canada geese to achieve intelligent international management of this great natural resource.

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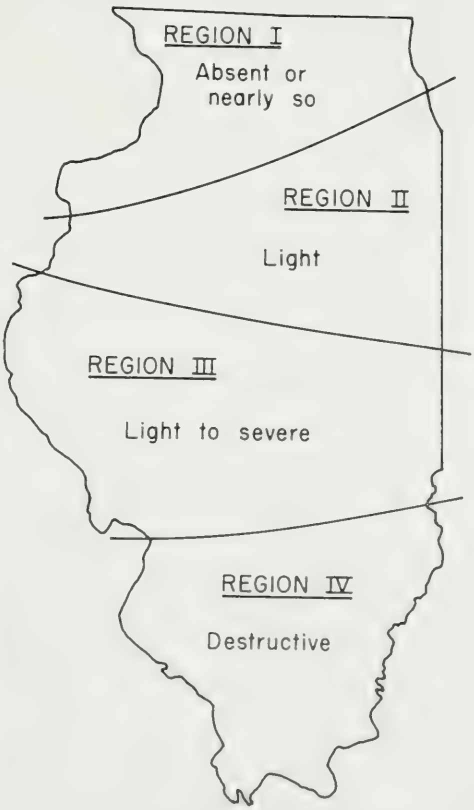
Corn Trouble

The farther south you go in Illinois the more the farmers are worried about Stewart's disease of corn. It is caused by a bacterium that produces two principal types of damage: an early-season wilt and death of the plants and a late-season leaf blight that may cause premature death of the plants. The disease is especially virulent in sweet corn but can be destructive to field corn as well.

The Stewart's disease bacteria overwinter chiefly in the bodies of adult corn flea beetles. These are little black shiny beetles about ⅛-inch long that jump like fleas and eat the tissues of the corn leaf. Early in the season, before the corn plants are diseased, the disease organisms exist only in the digestive tract of the beetles. When they feed on a corn leaf, they also excrete on it, and the bacteria voided in the beetle feces enter the corn leaf through the areas injured by the beetles' feeding.

This is only part of the story. According to Survey entomologist M. W. Sanderson, the overwintering beetle adults lay eggs, then die. The eggs hatch into larvae that feed on roots in the soil, pupate there, then the new crop of adults emerges in late summer. These again feed on the corn leaves, and, if the plant is diseased, the Stewart's disease bacteria become established in the digestive tracts of the new adults. At this time the mouthparts of the beetles get smeared with bacteria which the beetles transmit by jumping from plant to plant and chewing on the leaves. Late in autumn these infected beetles overwinter in ground litter, then start the cycle anew the next spring.

In his early surveys of Illinois plant diseases, Survey plant pathologist G. H. Boewe was struck by the sporadic nature of the disease outbreaks. Some years it would be destructive, other years light or nearly absent. Furthermore, the disease was almost invariably more severe in southern Illinois. Striving for some clue that might lead to predicting severity of



Predicted incidence and severity of Stewart's disease or bacterial wilt of corn for the early Illinois season. (Map prepared by G. H. Boewe.)

attack, he plotted various aspects of weather against disease incidence and finally found a remarkable correlation: the warmer the winter, the more severe the disease the next year. It appears now that cold weather reduces the survival of the flea-beetles and thus the chance of beetles infecting corn plants with the disease-producing bacteria.

With this as a starter, plant pathologist Boewe started summing mean Illinois temperatures for December, January, and February for about a hundred weather-reporting stations distributed throughout the state. From this information he worked out an index of winter weather severity. These indexes were checked against severity of Stewart's disease and found to be a remarkably accurate predicition of disease incidence for the following year.

Last month the eighteenth Boewe forecast of Stewart's disease in Illinois was distributed to farm advisers, sweet corn growers, market gardeners, and other interested persons. Its prediction is that Stewart's disease will be more destructive and occur much farther north in Illinois during the summer of 1966 than it did in 1964 or 1965. The forecasts by region are shown in the accompanying map.

Stewart's disease can be controlled either by using corn varieties resistant to the disease or by drastically reducing the numbers of beetles. Information about either control measure can be obtained from farm advisers or the Survey.

Not Catching?

Investigators of rabies in wild animals in the United States have discovered that more than 90 percent of the recorded cases are in either foxes or skunks. When cases were plotted geographically for each wild animal, a startling circumstance appeared. In certain areas many skunks but few foxes have rabies, while in other areas many foxes have rabies but few skunks do. There was remarkably little overlap between the skunk rabies and the fox rabies areas.

It had been noticed that the prevalence of rabies appeared to increase with the population density of susceptible hosts, leading to the preliminary thought that perhaps foxes were at a low population density in the skunk rabies areas and skunks were scarce in the fox rabies areas. Censusing proved that this was not the case.

Because the various rabies areas were based on reported observations of rabid wild animals rather than on testing samples of wild animals, Survey wildlife investigator B. J. Verts got the idea that perhaps the discreteness of the fox rabies and skunk rabies areas was a peculiar fluke of reporting. He and his colleague G. L. Storm then set about to learn the actual incidence of rabies in wild populations of skunks and foxes in northwestern Illinois and compared these with the number of cases reported to health authorities. They found that in Carroll County there was no significant correlation between the reported incidence of rabies among wild skunks and the true prevalence of the disease in wild populations (*INHS Reports,* No. 31, "Hidden Threat").

This year the results are back from the laboratory tests of red and gray fox brain tissue taken from animals trapped in the same area where skunk rabies is endemic. These figures bear out remarkably the discreteness of the skunk rabies and fox rabies areas. In northwestern Illinois, of the 362 skunks tested between 1958 and 1964, 31 had rabies. Of the 274 foxes tested from the same area during the same period, not a single one had rabies. This poses a neat question: by what mechanism does this disease apparently remain restricted to a single species in an area containing several other supposedly susceptible species? Are the strains of rabies different in the two species so that foxes are only slightly susceptible to skunk rabies and vice versa, or is this phenomenon due to differences in the behavior of the two kinds of animals? Wildlifer Storm will be seeking answers to these questions.

All Clear

On January 28, 1966, the U.S. Department of Agriculture canceled its permission for the use of aldrin and dieldrin as a foliage application on practically all field, forage, and vegetable crops. This

The puzzle of the skunk, one of Illinois' pretty and widespread native mammals: When rabid, why doesn't it infect its neighbor foxes in northwestern Illinois? (Photo by former Survey photographer William E. Clark.)

action still permits the use of aldrin (not dieldrin) and heptachlor for the control of soil insects attacking corn.

Survey entomologists W. H. Luckmann, H. B. Petty, and Steve Moore point out that these changes were anticipated and incorporated in the 1966 Survey insecticide guides for Illinois insect control, distributed on January first. Actually, the Survey recommended two years ago that no chlorinated hydrocarbons (of which aldrin and dieldrin are two well-known ones) be used on vegetable crops, and at that time urged dairy farmers not to use chlorinated hydrocarbons on dairy farms.

Anyone concerned about the USDA insecticide regulations may be assured that current Survey insect control recommendations are accurate and up-to-date sources of information for the farmer and vegetable grower.

Bottom of the Barrel

Before the dam was closed at the 600-acre Forbes Lake in Marion County, practically all fish were removed from the water shed so that the lake could be started out with a "stocked only" fish population. In 1964, after the lake was filled, it was stocked with large numbers of largemouth bass fry. To find out what had happened, Survey aquatic biologists D. H. Buck and C. F. Thoits sampled the fishes of the lake every month from April to September in 1965, completing their tabulations this last winter.

Worried because of possible fry kill in a new, untested lake, the lake was stocked originally with several times the number of fry per acre that is usually employed. It seems, however, that most of them lived because now the lake has a tremendous number of bass. A legal limit of 12 inches was set for these fish in 1965 and fishing was fairly good, indicating that a few of the larger bass did reach catching size. The disturbing thing that Dr. Buck reports is that the greatest bulk of the bass population is now between 6 and 8 inches long and showed practically no growth during the whole summer of 1965.

The reason for this was discovered when tabulations were made of the populations of other fish in the lake. In spite of extremely careful efforts to eradicate fish from the water shed before the lake was

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filled, a few bluegills and other small forage fish managed to survive and eventually moved down into the lake when the lake was filled. Apparently getting every last fish out of the drainage system is a virtual impossibility, and Dr. Buck says several concerted efforts to do this have been made in various parts of the country but as yet, without success. As a result Forbes Lake started out with a small number of several kinds of the native fish of the area including a few bluegills. It is the size charts made for the bluegill population that explain the situation found in the bass.

The surviving bluegills spawned in 1964, and by early 1965 the bluegill population had a size peak at about 4 inches. During the year the numbers of all sizes up to and including 4 inches dropped rapidly, until by September there was an almost complete lack of 2- to 4-inch individuals. Dr. Buck points out that these 2- to 4-inch bluegills are the chief source of food for the 6- to 8-inch largemouth bass. As the bluegill fry have gotten into the 2-inch range, they have been gobbled up by the hungry medium-sized bass. The latter have been so numerous that the small number of bluegills has provided only enough food for the bass population to maintain itself without any growth.

Foodwise, these bass are at the bottom of the barrel. The problem now is to reduce the bass population drastically. To accomplish this the Department of Conservation has removed the length limit on bass in the lake, and it is now up to the fishermen to improve their future fishing by taking small bass.

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JUNE 1966, NO. 44

Sick River

Sixty years ago the Illinois River teemed with fish and waterfowl. Special trains brought Springfield anglers to Havana for a day's fishing. Carloads of fish were shipped to eastern and northern cities. Duck hunting on the river and its flood-plain lakes and marshes was legendary. Today the game fish have almost disappeared, the commercial fisheries have dwindled to low figures, and some of the favorite kinds of ducks have practically vanished from the river. How great have the losses actually been? What has caused the decline? What can be done to improve the river? Survey chief H. B. Mills, aquatic biologist W. C. Starrett, and wildlife specialist F. C. Bellrose have pooled their knowledge to probe these questions in the Survey's recent publication *Man's Effect on the Fish and Wildlife of the Illinois River* (Biological Notes 57), now available for distribution.

Survey scientists have made special studies of the Illinois River since the beginning of the century. In 1903 C. A. Kofoid summarized his collections of microorganisms made in the river from 1894 to 1899. In 1908 S. A. Forbes and R. E. Richardson included detailed records of all the river's fishes in their classic volume *The Fishes of Illinois*. Forbes and Richardson continued to follow changes in the river through 1928. During the late twenties, D. H. Thompson made important observations on the river. For the last 30 years Starrett and Bellrose have been sampling and censusing the fish and waterfowl of the river.

Piecing together information from many sources and integrating this with the Survey's records, the three authors have brought together what can be described at best as a discouraging picture. The Illinois owed its primeval richness of life to its almost lakelike quality — a broad stream

Numbers of migrating canvasbacks on the Illinois and Mississippi rivers. Note the extreme reduction on the Illinois River. The complementary increase on the Mississippi in recent years is undoubtedly a partial replacement from the Illinois. (From *Biological Notes 57*.)

with little current, an abundance of bordering lakes and sloughs flooded during high water, and at all times rich with aquatic plants, large and small, that furnished food and shelter for its amazing abundance of animal life.

But the river and its tributaries run through some of the richest farmland in the world. As more and more of Illinois came under the plow, more and more silt was washed into the river, gradually producing a fine layer of silt choking out more and more plant life, clams, and other things on which the larger animals feed. Nearly half of the lakes and sloughs were diked off and farmed, not only reducing sources of food for fish and wildlife but contributing more silt to the restricted river.

Nine million souls live in the cities and towns of the Illinois River's drainage basin. Their effluents find their way into the river. Formerly these were discharged as raw sewage; even now sewage treatment plants are still inadequate to protect the river from excessive oxygen loss from pollution. As a result, sanitary pollution has at times threatened to wipe out the river's entire fisheries, which amounted to 24 million pounds of fish in 1908 but dwindled to less than a million pounds in 1964. Data assembled by Starrett show that bluegill catches in 1942 were 33 times greater than in 1964 and that largemouth bass, once an extremely abundant fish in the river, are now present only in isolated areas. Eighteen kinds of native fish have been completely obliterated from the entire river.

On the waterfowl side, the Bellrose data show that the lesser scaup ducks and canvasbacks have declined alarmingly in the last 20 years. Ring-necked ducks and ruddy ducks also declined. The cause seems to be the annihilation of aquatic insects, fingernail clams, and aquatic plants that form the food staples of these birds.

Dr. Mills points out that as a biological resource the river is steadily deteriorating, in spite of certain measures which have been taken to help stem the river's degradation — establishment of some wildlife refuges, development of hunting and fishing grounds, and improvement of some of the sewage disposal plants. He adds that we know many techniques by which the river could be greatly improved, but that for an effective attack on this problem more knowledge must be gained, and there must be a concerted effort on the part of agriculture, municipalities, industry, and individuals to translate knowledge into action.

Happy to Move

What happens to deer when they are moved to a new location? Do they have a homing instinct that urges them to try to find their old haunts or do they settle down peaceably in the new location? To get an answer to these questions, Survey wildlife specialists G. G. Montgomery and R. E. Hawkins moved 20 white-tailed deer from the Crab Orchard refuge at Carterville to the Dixon Springs Research Center at Glendale, a straight-line distance of about 30 miles.

Before being released, each deer was fitted with a miniature radio transmitter fitted as a collar around the deer's neck. Each transmitter has a potential life of about 18 months. The locations of each deer were monitored by a radio-tracking system that automatically recorded the deer's position once a minute. The blips on the radio-tracking system were converted to special cards, these were fed into a computer, and the computer recorded the locations on a map.

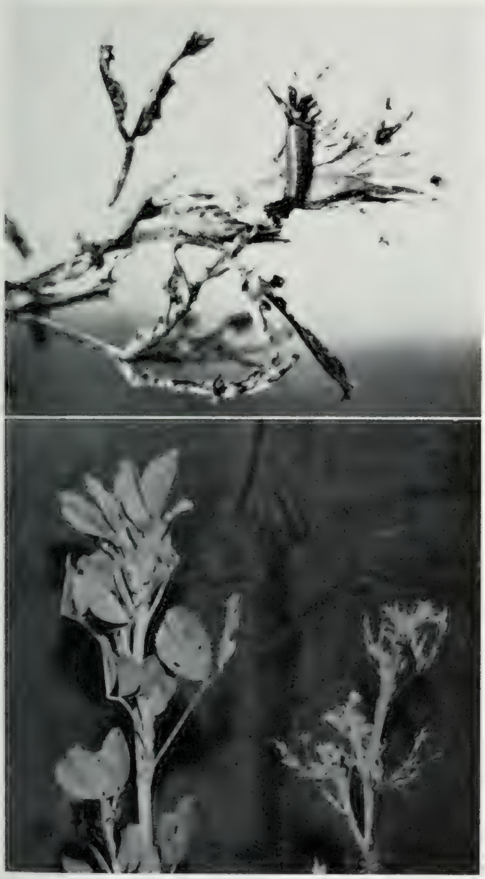
The results of the first three months' observations seem to tell the story. The relocated deer did not attempt to return to their original home but stayed in the new area. Here the animals have established new home ranges that usually include the place where they were released. A good example is deer No. 0049, an adult doe. Ninety-seven days after she was released in the new area she ranged over an area approximately 1 mile in diameter, and the point of her release site was near the center of this area.

This habit of "staying put" undoubtedly accounts for much of the success with which deer have been established in many new areas. On the basis of this experiment, it is presumed that if deer do not

stay in a new area, a lack of suitable living conditions in the new home would be the cause of their migrating.

No Joke

This spring, inexorably on schedule, the alfalfa weevil has struck southern Illinois. The utter destruction caused by the feeding of these insects can scarcely be believed by those who haven't seen it. The larvae eat the green leaves to the midrib; when defoliation is severe the plants turn yellow, then as defoliation continues to the ultimate and the leaf skeletons dry, the entire field turns almost white. This year in Illinois south of Route 13 (roughly Chester to Shawneetown) the alfalfa has been a total loss. One field that normally yielded 900 bales this year produced 178 bales, and those were only stems and of no commercial value. Practically every field in the area is affected just as badly. This is only the third year this insect has appeared in the area. Experiences in Kentucky indicate that even worse is ahead.



Injury by alfalfa weevil larvae. *Above*, defoliated branch with larva on it; *below*, alfalfa foliage protected from weevil injury at left, alfalfa badly defoliated by weevils at right. (Photos by Dr. Petty.)

No effective parasites or pathogens of the weevil are in sight for the immediate future. Three wasp parasites are being released, and a possible bacterial disease is being studied, but it will be several years before we can assess the effectiveness of these organisms. Survey entomologists W. H. Luckmann and E. J. Armbrust point out that successful alfalfa growing in southern Illinois will require carefully timed control measures, next year probably as far north as Route 40.

Dr. Armbrust, a new Surveyite from Cornell University in New York, where he has had much experience with the weevil, points out that it will often kill new stands, especially when the weather is dry. The first growth must be sprayed, then cut and the stubble immediately sprayed to protect the next growth. If the stubble is left untreated, the weevil larvae will eat the new growth as fast as it appears. In cooperation with extension entomologist H. B. Petty, reports and recommendations for specific control of the weevil are given every week in the *Insect Survey Bulletin.*

Dr. Luckmann points out that the days of carefree alfalfa growing are over in southern Illinois; in the near future this will be true in areas farther north. In the wake of the alfalfa weevil, successful production of alfalfa will require extremely good management, especially in watching the seasonal progress of the weevils and planning control measures against them.

On the Virus Trail

When Survey plant pathologists J. L. Forsberg and Walter Hartstirn began investigating virus diseases of gladioli in Illinois, they little realized some of the difficulties they would encounter.

Because many plant viruses are transmitted by insects, and insects cannot be completely controlled in the field, the work had to be done in a greenhouse that could

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be kept insect-free. This involved the use of gastight greenhouse compartments that could be fumigated regularly without disturbing projects in adjacent compartments where Survey entomologists were rearing insects. But the Survey greenhouse compartments, constructed before the days of fumigation, were not gastight. To remedy this deficiency, all glass in the partition walls was removed and reinserted with gastight seals.

To obtain information as fast as possible in the limited greenhouse space available, it was decided to grow the gladioli the year around with the expectation that proper forcing would produce two or three crops a year. In this endeavor the plants simply did not cooperate. Many of them refused to bloom during the short days of winter. To overcome this difficulty, the investigators tried increasing the length of day by artificial lighting. Five varieties were used in this test, but they did not respond equally to the additional light. This varietal difference in light physiology had not been suspected, but it adds new problems to the investigation.

In the meantime progress was being made in field experiments. Growers plant their glads from early April to mid-July in order to have a succession of cut flowers for as long a time as possible. The question arose as to whether time of planting had any effect on virus incidence. Two hundred and fifty corms of each of 42 varieties were selected from commercial stocks; 125 corms of each variety were planted in early May and the remainder were planted in late June. In 36 of the 42 varieties the incidence of white break disease was greater in the late planting than in the early planting. This phenomenon raised more questions. What caused the greater amount of virus disease in the late planting? Will this extra "dosage" of virus carry over in the corms?

The two scientists point out that starting any new research endeavor leads to unforeseen circumstances and unpredictable problems. In these studies there are also the extreme technical difficulties encountered whenever a virus is studied. As Dr. Forsberg says, "This is as tricky as working on the common cold."

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JULY 1966, NO. 45

The Biological Clock

Homeowners, farmers, and grounds keepers have frequently been alarmed at the appearance of large brown areas in home lawns, permanent grass pastures, and golf courses. The brown grass on these areas could often be peeled back like a carpet, revealing a mass of cut grass fragments and small silk-and-grass tunnels or nests containing greenish caterpillars up to nearly an inch long. These are sod webworms, the larvae of narrow-winged moths often seen flying over the grass or attracted in large numbers to lights.

Webworms overwinter in the ground as larvae. In spring they feed on the grass and complete their growth, pupating in their silken tunnels. In late May or early June the moths emerge, mate, and lay their eggs. The female moth lays about 500 eggs, dropping them singly while either sitting on a grass blade or flying low over the grass. The eggs hatch into little caterpillars that eat the base of the grass stems, causing the upper part to die and form the brown loose mat. Each summer there are two overlapping generations of most species of Illinois sod webworms. Larvae present in late fall hibernate through the winter.

Seeking details of webworm habits, Survey entomologists G. C. Decker and A. C. Banerjee found little activity of the moths during daylight hours, so set up continuous observations during the night. They found that adult emergence from the pupae does not start until practically complete darkness, when light meters registered zero foot-candles. Maximum emergence occurs between 9 p.m. and 1 a.m., and mating soon follows, continuing until dawn.

Typically, egg laying begins at dark the night following emergence and mating. The fertilized females grow restless soon

Nest, pupa, and larva of sod webworm. Nest contains old cocoons of a parasitic wasp that parasitises the webworm larva. (Photo by Survey photographer Wilmer Zehr.)

after sunset and begin laying eggs when the light intensity falls below 1 foot-candle; about 60 percent of the eggs are laid in the first hour and 30 percent during the second hour of darkness. After resting for 24 hours, the female moths again lay eggs at the same period at the approach of total darkness, and keep up this rhythm for 5 or 6 days. The hour when egg laying begins is later in June and July, earlier in September when the daylight period is shorter. Moonlight apparently is not bright enough to affect the normal nocturnal activities of the moths.

In testing the role of light values as a stimulus to oviposition, Drs. Decker and Banerjee put moths in rooms with artificial light in which they could produce days of various lengths and cycles of day and night lighting that were the opposite of normal. When the day-night cycle was reduced below 16 hours (versus the normal 24-hour cycle), the moths did not react normally. Under continuous 24-hour illumination they refused to lay eggs. When night and day were twisted around, however, they soon adjusted to the new cycle and laid eggs promptly when the light intensity approached zero foot-candles.

It thus appears that these insects have a remarkable internal clock regulating practically all of their activities, a clock that is turned on and off by normal daily changes in light and darkness.

Angling Angle

This season tests are continuing on the effect that added fish food has on fishing. The fish at Ridge Lake, eight miles south of Charleston, are again receiving prepared fish-food pellets to supplement the natural foods in the lake. As in 1965, about three pounds of food per acre per day will be added during June, July, and August. The pelleted food is not distributed evenly throughout the lake but is spread from the boat pier and over several active bluegill spawning beds in various parts of the lake. As a result, the fish in these areas are undoubtedly getting more than their share of the food. They are fat and apparently very trusting.

Feeding was begun in April when the water warmed above 60°F. and continued in May as soon as the water warmed after the cold periods early in the month. Fishing was not begun until June 11, so the fish had a chance to learn to eat the food without being molested.

Survey aquatic biologist G. W. Bennett reports that fishing for the first week of the season has confirmed several observations and predictions made last season, when the program of adding fish-food pellets was initiated. In seven days cooperating fisherman caught about 160 largemouth bass and about 700 bluegills. The bass were small for this species, confirming last year's observation that they do not feed on the pellets. The bluegills were exceptionally large, indicating that the bluegills were probably eating the major portion of the food pellets. One fisherman armed with a cane pole and some worms can well attest the trusting nature of the fish — he started fishing while still tied to the laboratory pier and caught 29 large bluegills without moving.

The Ridge Lake fish yield in 1963 and 1964, before feeding was started, was 14.7 pounds per acre and 30.1 pounds per acre respectively — a very poor fishing record. In 1965, the first year of feeding, the catch jumped to 68.1 pounds per acre. The 1966 season promises to be even better. The bluegills which benefitted from the feeding program in 1965 are continuing to take the food in 1966 and are growing much larger than any of the bluegills present in the lake in 1965. Unlike birds and mammals, these cold-blooded vertebrates have no definite limit to adult size and continue to grow throughout life. If a large supply of food is available to a fish for a long enough period of time, it may grow to an exceptionally large size for its species. Mr. H. W. Adkins, summer biologist in charge of the fishing at Ridge Lake, avers there is a bluegill at least 10 inches long and weighing at least one and one-half pounds feeding under the laboratory pier. As yet no one has caught this fish. Mr. Adkins will continue to feed it twice daily so it will be available to any fisherman cooperator who is lucky enough to hook it. Fishing at Ridge Lake is con-

Joe Authenrieth and Earl B. Sumerlin, two of the 500 fishermen who will cooperate with the Ridge Lake fishing tests this summer. (Photo by Dr. Bennett.)

trolled by the Survey, where inquiries concerning regulations should be directed.

Did Jack Frost Do It?

The late freeze of this spring killed early growth on many kinds of evergreens and broad-leafed trees, causing conspicuous brown dead twigs and leaves that are still hanging onto many trees. Survey plant pathologist D. F. Schoeneweiss reports that certain other types of injury resemble freeze injury and are being mistaken for it. Sycamores had many leaves and twigs killed by anthracnose, a fungus disease that produces injury similar to freeze damage. Many varieties of junipers and red cedars are susceptible to twig blight caused by a fungus that kills twigs scattered over the plants.

Many trees are affected by a noninfectious trouble called *scorch* that resembles freeze injury. It develops as yellowing, browning, or wilting of leaf tissues and may be caused by internal physiological disturbances, drought, girdled roots, or having a soil area too limited for good growth.

Dr. Schoeneweiss points out that many of these conditions can be greatly helped by watering, the proper kind of fertilization, the application of proper fungicides, or a combination of these methods. Information on these aids may be obtained from the Survey.

So Little Means So Much

Not many years ago hunters thought of the Sibley area in east-central Illinois as a paradise for pheasants. This heavily farmed area produced large numbers of these birds year after year. Since 1962, pheasant numbers declined steadily, until by 1965 hunting success had decreased materially. For one reason or another, hunting success is not always a good index of the actual population of birds in an area, but figures compiled by Survey wildlife specialists more than bear out the hunters' reports.

Project leader W. J. Francis has recently completed tabulations of four measures of population density: (1) the population calculated from the recapture of tagged birds, (2) broods of birds observed along 640 miles of roadside, (3) the number of chicks observed along this same 640 miles, and (4) the number of successful nests found in various diligently searched sample plots scattered through the area. Plotted year after year, all four results show a remarkably similar steep slope from high-density to low-density populations. In the study area the fall population of pheasants dropped from 20 to 25 percent per year in 1963, '64 and '65, with the result that the 1965 levels were only about a third of the 1962 population.

Results of a study of agricultural land use and pheasant nesting explain this population decline. During the high-population year 1962, over a hundred successful pheasant nests were found in the sample plots, about 70 of them in hayfields, and another 10 in pasture. Very

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few were found among small grains, none in corn or soybeans. In the low-population year 1965, on the same sample plots, only 25 nests were found, of which 18 were in strip cover, only 2 in hayfields, the remainder in various situations. The big drop from '62 to '65 was therefore a reflection of a tremendous drop from more than 70 down to 2 nests found in hayfields, accentuated by the drop from 10 to 0 nests found in pasture.

When wildlifer Francis tabulated the percentages of land in various crops, he found that in 1962 hayfields constituted 13 percent of the study area but after that year the acreage in hay had decreased steadily, in 1965 reaching a low of 2 percent. The acreage taken out of hay was used chiefly to increase acreages of corn and soybeans, in which pheasants normally do not produce successful nests. This change in land use was the result of decreasing participation in the Federal Feed-Grain Program by the the farmers in the study area.

About 4 percent of the area has consistently remained in strip cover, which consists chiefly of the grassy areas along country roads, fence rows, and the edges of fields. During the decline in hay acreage, production of pheasant nests remained almost the same year after year in this strip cover. As the population as a whole decreased, this constant production in strip cover represented a greater and greater portion of the total pheasant population, amounting to over half of it in 1965.

From these figures it appears that last year the small, constant, 4 percent of strip cover provided most of the nesting sites for the pheasants in the Sibley study area.

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AUGUST 1966, NO. 46

Lone Star Tick in Illinois

This latest addition to the Illinois scene is certainly not a welcome one. Although slightly smaller than the size of the well-known common wood tick, the lone star tick inflicts a much more painful bite that often causes swelling of the skin and severe, prolonged itching. Its beak is longer than that of the wood tick, and when attached lone star ticks are pulled off the body, the beak usually breaks off and remains embedded in the tissue of the victim. Although a potential carrier of Rocky Mountain spotted fever and tularemia, the lone star tick does not seem to be a common transmitter of these diseases.

This tick has been known for some time to be in Kentucky and Missouri only a few miles from Southern Illinois, but diligent search for it over the past twenty years unearthed no Illinois record. Last winter, however, Survey wildlife specialist G. G. Montgomery found the first specimen on a deer in Pope County. This spring and summer he has picked up additional specimens from both Pope and Williamson Counties.

Although primarily a deer tick, the lone star tick will bite human beings and domestic animals. Entomologist L. J. Stannard, the Survey's tick specialist, points out that the habits of this tick are noticeably different from those of the wood tick. The early stages of the wood tick feed chiefly on mice and other small animals; only the adult stage bites humans and this stage occurs most commonly in the spring. By contrast, all stages of the lone star tick bite humans; these ticks are most abundant in August when all stages are present.

Outside of Illinois, the lone star tick has a wide range, occurring through Central America and the southern United States to the Atlantic coast. In the United States it is most abundant south of the latitude of southern Illinois, but it has been found sparingly in the northeastern states. There is one Canadian record from Labrador. According to Dr. Stannard, this could mean that the lone star tick may not become widespread or abundant in Illinois but nevertheless Survey wildlife specialists and entomologists plan to keep this tick under close surveillance.

Adult female of lone star tick, *Amblyomma americanum*. Length of body about 1/10 inch. (Photo by Survey photographer Wilmer Zehr.)

King Quail

The bobwhite, named for his clear piping call, is considered by many hunters to be the true royalty of Illinois' game birds. To these enthusiasts, nothing is better music to the ear than the whir of a covey of quail exploding underfoot.

Quail have occurred abundantly in the mixed scrub and prairie country roughly south of a line connecting Jacksonville, Springfield, Mattoon, and Paris. In an effort to find ways of increasing quail populations and increasing quail hunting in the northern half of this area, Survey wildlife specialists began intensive studies in 1962 on quail habits and food and cover preferences in this area. Because of increased intensity of farming, however, two study areas had to be abandoned because the forest edge habitat became too reduced to support quail populations large enough to study experimentally.

In 1963 Survey wildlifer J. A. Ellis began cooperative bobwhite studies with the Illinois Department of Conservation on the Sam Dale Lake Conservation area in Wayne County and Stephen A. Forbes State Park in Marion County. Through 1965, management of the area consisted chiefly in planting patches of food consisting of corn, wheat, milo, buckwheat, and several millets. It was hoped that these food patches would be particularly useful to the birds during winter, especially when snow covered the ground. A rotation was also established on some of these areas involving annual food plots, grasses, and clover in large open fields that were subdivided by permanent plantings of pine and multiflora rose. The idea of the tree and shrub strips was to create more woods edge.

By March, 1966, it was evident that the bobwhite population had decreased more than 50 percent below the 1963 levels. In an effort to discover what might be the cause of the decline, wildlifer Ellis tabulated his observations on the food found in crops of killed birds, vegetation in the vicinity of roosting sites, the vegetation in the vicinity of the exact spots where coveys had been flushed, and records of the recapture of tagged birds.

First it was found that the quail made relatively little use of the planted food patches. Many birds ate some buckwheat, German millet, and lesser amounts of corn and wheat. The prime staples of food, however, were produced by some of the wild plants growing in the area, especially cut-leaf ragweed, lespedeza, and acorn fragments. These are also food staples for quail in other areas of southern Illinois. Especially enlightening was the fact that quail rarely visited the food patches when snow was on the ground.

The Ellis data introduced another peculiarity of quail habits. Although the quail were flushed and were found roosting outside the wooded areas, they were never far from them, seldom over a hundred yards. Many of the food patches were as much as ¼ mile (440 yards) from wooded sites, and it may be that the quail did not feel safe so far out in the open.

The final, and probably most important, conclusion drawn by Ellis was that the type of rotation in the managed areas produced a very heavy cover of matted grass and stems through which quail cannot move easily and in which they have difficulty finding food. It has been found in more southern areas that quail like habitat in which the ground surface itself is fairly open, allowing the quail to run beneath the shrubs and herbs arching above the ground and making seeds and acorns on the ground much easier to see. The luxuriant weedy cover following seeding and fertilization of food patches and the permanent grass and legume areas apparently form too dense a mat.

In other parts of the country controlled burning of patches of the habitat has been found satisfactory in reducing dense mats of dead vegetation on the surface and in encouraging the growth of plants such as cut-leaf ragweed that produce the kinds of ground cover that quail are dependent upon. In the next set of experiments in these areas, a system of experimental burning will be initiated to see if it will result in greater quail populations.

Movement Tester

Scientists studying tree diseases caused by fungi keep hoping for the perfect easy cure — some chemical that can be injected into a tree, will spread throughout the tissues of the tree, and kill the fungus. They encounter a serious problem. Because both the tree and the fungus are plants, both host and parasite have similar reactions to the chemicals. As a fungicide chemical builds up in the tissues of the tree to the point where it would kill a particular fungus, almost invariably it will also kill the tree. But the search still continues for a chemical that will kill the fungus and leave the tree in satisfactory condition.

Such a chemical must have the property of moving through the tissues of the tree and remaining active against the fungus. The chief path for these chemicals is through millions of little tubes in the wood and bark, called the vascular system, through which water and nutrient materials are transported. Some chemicals appear to be transported readily throughout the vascular system, whereas others will scarcely move from the point of injection. Because of this difference in transportability, one of the first tests concerning prospective new internal chemicals is to determine whether or not they will move in the sap stream of the plant.

Until recently methods of making translocation tests have been either extremely time consuming and requiring a large amount of complicated equipment, or they have not been sufficiently sensitive to detect the translocation of low chemical concentrations. Last winter Survey plant pathologists E. B. Himelick and Dan Neely devised a relatively rapid and highly sensitive method for testing the transport of chemicals affecting fungi. Their method employs quarter-inch disks of thin cellophane through which water and dissolved chemicals will diffuse rapidly. Briefly the main steps of the technique are as follows, illustrated in photos A to F:

Testing transport of chemicals through plant stems. Steps A to F explained in text. (Photos by Survey photographer Wilmer Zehr.)

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A. A 16- to 24-inch cutting with leaves intact is placed in a solution of the chemical for 24 hours. Evaporation from the leaves would pull any transportable chemical through the vascular system.

B. Each cutting is severed above the surface of the bottle, the leaves are removed and small sections cut from that portion of the stem that was 10 to 12 inches above the liquid.

C. Each of these small sections is placed in a petri dish containing distilled water and extra thick filter paper that helps to support them.

D. A cellophane disk is placed on top of each twig section.

E. Using a fine glass capillary tube, a small quantity of spores of the test fungus is placed on top of each cellophane disk.

F. After 24 hours the cellophane disks are removed from the twig sections, placed on a microscope slide, and examined under the microscope to see the condition of the test fungus.

If the fungus spores on the cellophane have germinated and grown normally, the chemical has not been transported through the tissues. If the fungus spores have either failed to grow or been killed, the chemical has been transported through the tissues of the plant.

Drs. Neely and Himelick are continuing to work out improvements on their new technique. This more sensitive bio-assay test will be a great aid in getting more accurate information in this intriguing field and should greatly speed up efforts to find systemic aids for diseased trees.

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SEPTEMBER 1966, NO. 47

Pumpkin Eater

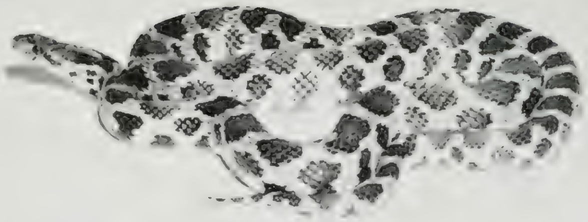
When you see the long, sturdy pumpkin vines snaking through the field, and the wagonloads of gorgeous orange pumpkins headed for the cannery, it is easy to forget that all this arose from tender little sprouts pushing through the soil the previous May. Growing from germinating seeds an inch deep in the soil, these shoots form first the leaves and vines, then the flowers and fruits of Illinois' annual 120,000-ton pumpkin crop, first in the nation.

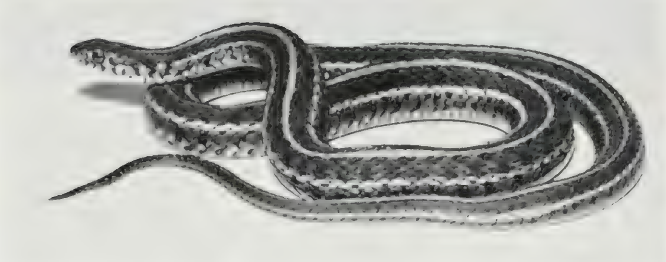
The germinating seed and young shoot are extremely vulnerable to attack by maggots of a small fly called the seedcorn maggot. Especially during winter and spring, this maggot may be sufficiently abundant to destroy a large percent of the seeds and very young germinating shoots. In an effort to find some simple remedy that would protect this very young stage, Survey entomologist D. Broersma experimented with coating seeds with some of the newer systemic insecticides. He applied a solution of insecticide to the seeds, which were allowed to dry before planting; 2 to 4 ounces of insecticide were used per hundred pounds of seed. This produced no damage to the pumpkins themselves, but did a good job of killing the seedcorn maggots attacking the seed and seedling.

Checking his experimental plots when the seedlings had just broken through the ground, Dr. Broersma noticed clusters of dead striped cucumber beetles along certain rows. Investigating further, he found that the minute a pumpkin sprout gets close enough to the surface to make even a tiny crack in the soil, these little beetles dig down in the soil and feed on the young shoot. In Illinois, no matter what the weather, they appear to be a constant and abundant feeder on this early tender growth, killing many of the seedlings and greatly reducing the size and vigor of those that do manage to grow and vine. This early stunting delays the establishment of satisfactory vine growth, reduces the number of flowers and delays the entire blooming period, causing an overall reduction in the per-acre production of pumpkins.

It was apparent that the new systemics that Dr. Broersma had applied for controlling the seedcorn maggot were proving remarkably effective against the striped cucumber beetle also. This early beetle attack is by the adults, which lay eggs in the soil, which in turn hatch into worm-

Adult of the striped cucumber beetle (actual length of head and body ¼ inch). (Photo by Survey photographer Wilmer Zehr.)





The two common garden snakes in Illinois. *Above*, an adult fox snake about 3½ ft. long; *below*, an adult plains garter snake about 2 ft. long. (Photos by Isabelle Hunt Conant.)

like larvae that also feed on the underground stems. So effective were certain systemic insecticides, that adult beetles died almost immediately after eating only small bits of plant tissue and before they had a chance to lay eggs. Normally the adults continue to eat the more tender parts of the plants and flowers. The systemics protected the whole plant for 4 to 6 weeks, giving protection against practically the entire length of life of the first generation of beetles which peaks early in June. The second generation, which reaches its greatest numbers in late July, attacks chiefly the flowers, and other remedies must be found to protect the crop at this time.

Dr. Broersma's treatment has resulted in greater vine growth, earlier flowering, an increase in number of flowers, and a substantial increase in pumpkin production. It promises to be highly beneficial to the operators of Illinois' 5,000 acres of pumpkins, grown chiefly in the central and north central parts of the state, and producing 65 percent of the entire U.S. pumpkin supply. Dr. Broersma points out that these results are still in the experimental stage but are nevertheless extremely promising.

Differential Effect

The use of herbicides for the control of aquatic plants introduces into the aquatic environment chemicals whose action on fish and other organisms is still poorly understood. This is well illustrated in recent investigations by Survey biochemist R. C. Hiltibran in his studies on the effect of various herbicides both on aquatic vegetation and on the fish in the same water.

In a recent series of tests, Dr. Hiltibran found that different types, called esters, of the herbicide 2,4-D were all equally toxic to aquatic plants but varied greatly in their effect on bluegills. He found that in general the high-volatile 2,4-D esters were toxic to bluegills at levels as low as 0.5 to 2.0 ppm (parts per million), whereas some of the low-volatile esters were not toxic even up to concentrations of 40 ppm. This means that fish toxicity tests need to be made on practically every formulation of an herbicide, because different types of the same general compound may have entirely different effects on fish than on water plants.

Another interesting item came from Dr. Hiltibran's studies with the formulation known as dimethyl 2,4-D. This was much less toxic than some of the others, with no lethality up to 40 ppm. In his first tests of this type of 2,4-D, Dr. Hiltibran was perturbed to discover that the fish had disappeared from the tank but were later discovered back in the corner on the floor. Watching the fish in later tests, it was evident that this compound irritated the fish greatly and they jumped out of the tank. This suggests the possibility that use of certain herbicides may actually drive fish out of the treated area because of the irritability of the herbicide. If such an herbicide were used to clean out vegetation that was too dense to allow fishing, it would also ruin the fishing.

Snakes in Your Backyard

Although Illinois' forty-odd kinds of snakes include many graceful, beautiful creatures, a surprising number of people do not seem to enjoy finding them in their backyards. The Survey's reptile specialist P. W. Smith receives many letters and calls every year from Illinois residents requesting information on eradicating snakes in lawns, gardens, and even in homes.

The majority of complaints come from the northern half of Illinois, where the plains garter snake and fox snake are common and frequently live near homes. The garter snake feeds primarily on an introduced earthworm common in gardens; the fox snake feeds on mice that abound near human habitations. Both snakes are harmless, but unfortunately the fox snake is sometimes mistaken for a poisonous snake. It has a copper-colored head, and when angry often vibrates its tail tip. Its pattern and head shape, however, are quite different from those of the copperhead and the rattlesnake.

Snakes have a major peak of activity and apparent abundance in spring and fall. Thus the housewife plagued by backyard snakes in April can be confident that by late June she is not likely to see another snake until late September.

Dr. Smith points out that safe and effective poisons and repellents have not been developed because snakes feed only on live prey and do not eat poison bait. Their shape makes trapping impractical. The best way to eliminate snakes is to remove rotting stumps, boards, and litter under which they like to rest, and to keep retaining walls and foundations in good repair so that snakes cannot crawl into crevices and hollows.

Where and Why

Whether interested in controlling rats, planning new releases of deer, or increasing sagging populations of game animals, the mammalogist needs a great deal of information about the movements of mammals. But obtaining accurate information on mammal movements has proven an evasive and often frustrating effort. Some of the largest mammals can be observed directly at sufficiently great distances that they are not disturbed by the observer's presence, but this method is subject to great limitations imposed by daylight, terrain, or density of vegetation.

Sometimes animals can be trapped, variously marked or banded, then released and recaptured. The results of this type of observation are open to various questions as to how the observations should be interpreted. Biologists have been tagging animals with radios and picking up the signals with directional receivers. This method also has certain limitations depending on the size and extent of movement of the radio-tagged animal.

In spite of the inherent difficulties, biologists for the last sixty years have persevered in their efforts to find out details of movement of different kinds of mammals, devising many clever techniques to obtain more and better information. As a basis for planning some of the Survey's mammal studies, Survey wildlife specialist G. C. Sanderson decided that it was time to take a hard look at the various techniques that had been used, what kind of information they had produced, and the general state of knowledge concerning mammal movements. His review of specialized scientific articles on the subject (available at the Survey) indicates that many of the marking and retrapping techniques gave extremely limited information, and that much of the information might not represent natural movements but movements influenced by the observer's actions in handling animals. Many of the studies were of too short a time duration to give information as to either the full range of the animal's activities, or chronicle its movements through different seasons of the year. In spite of these shortcomings, a great deal of excellent information has been accumulated.

In Dr. Sanderson's opinion, the techniques for locating and observing animals appear to be far ahead of the techniques for interpreting the information they give. More meaningful interpretations will result from finding out what an animal is doing at a particular place at a particular time, why it is doing it, and how its pat-

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tern of activities fits into its year-round needs for successful survival and reproduction. The most promising techniques for finding some of this information involve miniature radio transmitters and telemetry, but here we need better computer programming in order to unscramble the vast number of data that telemetry can provide. Survey engineer-biologist W. W. Cochran, Jr., and Survey biologist G. G. Montgomery are investigating this problem.

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OCTOBER 1966, NO. 48

Drought and Trees

Many trees and shrubs throughout central Illinois may have suffered greatly from the severe drought conditions that extended from early June to mid-September. Although the effect of drought on cultivated crops can be measured soon in reduced yields, injury to trees and shrubs may not be apparent until the following spring.

In checking reports of drought injury, Survey plant pathologist D. F. Schoeneweiss points out that trees and shrubs sufficiently drought stricken to wilt and lose their leaves are likely to die. On others that are less severely affected, leaves may change prematurely to their fall colors and drop earlier than they normally would. Drought-injured evergreens such as pine, spruce, and fir may lose older needles, or young shoot tips may wilt and turn brown. More often, however, drought causes injury to the small, tender, feeder roots that supply the plant with water and the nutrients that make vigorous growth possible. These trees and shrubs will not show normal growth the following year and will be so weakened that they will be unusually susceptible to winter injury, fungus diseases, and insect damage.

Drought-affected birch, poplar, willow, and ash are especially susceptible to injury by wood-boring insects and fungus diseases attacking stems and trunks. Damage from either of these causes is not apparent to the untrained observer until the affected stems or trunks become girdled and branches or trees die. A close watch should be kept for symptoms of stem or trunk attack, and weakened trees should be given preventive treatments of insecticides in early spring. Branches attacked by disease or insect pests should be removed and burned.

For trees and shrubs that were not watered through the drought period, and especially those whose leaves turn to fall colors prematurely, Dr. Schoeneweiss suggests two treatments: (1) fertilizing the plants well and (2) pruning them fairly heavily. Pruning reduces the number of leaves (which evaporate water) for the

Cottonwood tree with dead upper portion, a type of injury often associated with weakening due to drought. (Photo by Dr. Schoeneweiss.)

following year in order to balance the reduction in roots (which take in the water) caused by the drought. He warns that, in pruning, many diseases can be transmitted from plant to plant on contaminated pruning tools. It is therefore advisable to sterilize pruning tools in chlorox between treatments of individual trees.

Details of fertilizing and pruning, and other items of tree and shrub care are outlined in the Survey's recently published Circular 51, *ILLINOIS TREES: Selection, Planting, and Care,* and Circular 52, *Fertilizing and Watering Trees,* by the Survey plant pathology staff. These circulars can now be obtained by writing to the Survey.

The Unfathomable Fisherman

The unpredictability of when fish will bite is legendary; it is becoming obvious that when fishermen will fish is equally unpredictable. For the last twenty-five years, more and more studies on management of game fishing have included the gathering of information concerning the fishermen as well as the fishing. Records are kept on the number of persons fishing, the number of hours spent on the water, the number and weight of fish caught, the amount spent for tackle and bait, and the distance and directions traveled to reach the fishing grounds. From figures starting with Survey aquatic biologist G. W. Bennet's creel censusing, begun in 1942 at Ridge Lake near Charleston, a most interesting compilation has accumulated on the economics of game fishing in the state.

When these observations are analyzed in terms of angler attitude and fishing effort, it is obvious that fishermen in different states or areas react differently to fishing. This is brought out graphically in the Survey's recent Bulletin article, *Stocking and Sport Fishing at Lake Glendale (Illinois),* by aquatic biologist D. F. Hansen. Previous figures in Michigan indicated a rather close relationship between fishing effort and quality of the fishing, but Dr. Hansen found that this did not hold at Lake Glendale. Weather seemed to have a considerable effect, especially if abnormal weather occurred in spring when fishing is usually heaviest. Fishing interest generated in a period of excellent fishing appeared to carry over sometimes for a year or two after the quality of the fishing had decreased greatly. News of good fishing travels much faster and more widely than news that fishing has dropped off. Usually only good fishing or a change for the better is considered newsworthy.

Fishermen show a wide range in motivation. Some of them like to fish whether they catch much or not. Some consider that one good fish a day is a better conversation piece than the limit in half an hour. Some like to use only a fly, others only a plug, and so on. And many fishermen scorn changing their methods of fishing even when other methods are highly successful and theirs are not. Some like to fish only certain bodies of water, whether the fishing is good or not, others go from lake to lake in search of the best catches.

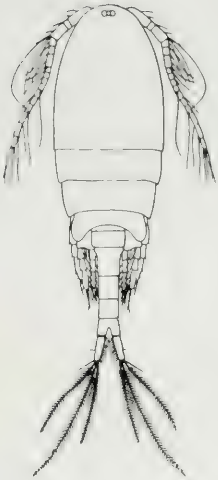
The one thing common to all fishermen is that they are a dedicated, persistent lot.

Salute to a Pioneer

The death, on September 8, 1966, of Dr. Ernest Browning Forbes, 89, Professor Emeritus of Pennsylvania State College, marked the passing of one of the oldest living former members of the Illinois Natural History Survey. He was one of the galaxy of young scientists gathered by his father, Stephen Alfred Forbes, first Chief of the Survey, to investigate pollution in the Illinois River.

Survey scientists had noted that by 1890 the Illinois River received the untreated wastes, both industrial and sanitary, of over a million people. At that time the lower reaches of the river showed little deleterious effect of the pollution, but the growth of Pekin, Peoria, Peru, La Salle, and especially Chicago, made biologists apprehensive that conditions downstream could worsen rapidly.

Marshaling all the resources he could, the senior Forbes organized a group of young biologists to study the Illinois River as it was then, in order to establish bench marks for measuring future changes. To this group belonged young E. B. Forbes, who worked as a zoologist from 1894 to 1896 and 1899 to 1901. His particular assignment was to study minute aquatic



Right: Dr. E. B. Forbes at the time of his retirement. *Left:* Illustration of a species of Cyclops reproduced from Dr. Forbes' 1897 report. (Photo of Dr. Forbes provided by courtesy of his grandson, Dr. R. M. Forbes.)

organisms called Cyclops, one of the water fleas. These abundant tiny animals form a link in the food chain from even tinier plants and animals up to fish. His Cyclops report was published in Volume 5 of the Survey's *Bulletin* in 1897.

To E. B. Forbes and his colleagues of that early scientific venture — thanks for the heritage of information. We could never go back and collect it again.

Tap Water

The drops of water or flakes of snow falling out of the sky follow a varied path from the place they land to your tap. Some hit roof tops or streets and are hurried through man-made channels into streams and reservoirs. Others meander down through the soil and slowly drain into brooks and streams or sink deep down through layers of porous material to form the reservoirs for our well water.

Since the introduction and widespread use of long-lived insecticides on large acreages of farm land, there has been concern that dangerous amounts of these insecticidal chemicals might leach out of the soil into domestic water supplies. To investigate this possibility, Survey entomologist W. H. Luckmann and Dr. Edward Press of the Department of Public Health, Acting Chief of the Division of Foods and Dairies, worked out a cooperative program to sample and test twenty major watersheds supplying water to municipalities in Illinois.

The Survey's entomologist-chemist W. N. Bruce, using specially designed equipment that can detect one-billionth of a gram of insecticide, found no detectable amount of insecticides in any of the raw or finished water samples collected in this study. He points out that this discovery is not at all strange. Chlorinated hydrocarbons such as lindane, DDT, aldrin, and heptachlor are the soil insecticides used most extensively over the state at present. These chemicals are remarkably insoluble in water. Lindane, which dissolves most readily, is nearly 1/1000 per cent soluble in water, but it is used in such small amounts in the state as to present no problem. The other chlorinated hydrocarbons have solubilities of around 1/400,000 per cent, which is very, very little. In addition, these chlorinated hydrocarbon compounds become bound very tightly to organic material or colloidal clays in the soil, and in this bound condition do not go into solution in free water. Thus, even in soils containing a moderately high amount of chlorinated hydrocarbon insecticides, free water percolating out of it contains only one or two parts per trillion of dissolved insecticide.

If a gully-washer carries suspended material into the water in the form of mud or silt, the amount of insecticide would presumably increase as it was carried temporarily on particles suspended in the raw water. When water treatment plants filter

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out the mud, the chlorinated hydrocarbons would remain bound to it and also be screened out of the water that would eventually reach the tap.

Dr. Bruce points out that the situation is quite different with the organophosphate insecticides that are gradually replacing the chlorinated hydrocarbons. Most of these have a solubility of 1/10 per cent to 2 per cent, and do not bind to soil particles. Unlike the chlorinated hydrocarbons, however, they have a relatively short life. When dissolved in ground water that is slightly alkaline, most of these would last only a matter of hours; in more acid ground water their lives would be in the neighborhood of days or weeks.

Up to the present time, none of these has been detected in domestic water supplies, but the acreage of their use in Illinois is still relatively low. As their use increases (especially in areas close to city reservoirs), a hazard could develop. Although this is highly unlikely, strategic water sources will continue to be monitored for these chemicals.

As new insecticides become employed, it will be necessary to make comparable studies on their solubility, binding properties, and length of life. Also required will be comparable monitoring in order to guard against contamination that could be hazardous to the water user and disruptive to farm practices.

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NOVEMBER 1966, NO. 49

A New Friend

Since its discovery in southern Illinois in 1964, the alfalfa weevil has spread rapidly and now infests 83 of the 104 counties in the state. It appears destined to become a destructive pest throughout the state in a few years. There is no doubt that its lack of effective natural enemies is one reason the weevil builds up to such tremendous populations.

Many kinds of insects are attacked by a variety of microscopic internal parasites including bacteria, fungi, and protozoans (microscopic one-celled animals). Although the alfalfa weevil has been under intensive study since its introduction into the continent over sixty years ago, only one disease organism has been reported in the United States, a fungus called *Beauveria*.

Parasitism by this fungus is extremely erratic. The fungus spreads by tiny resistant spores that apparently get on the skin of a larva where they germinate and

Highly magnified spores of *Nosema* in muscle tissue of alfalfa weevil larva; each spore is about 1/50,000 of an inch long. (Photo by Dr. Maddox.)

produce tiny fungus threads. These fungus threads penetrate the body wall of the larva, then produce a mass of fungus threads inside the body and eventually destroy the insect. The erratic nature of *Beauveria* attack apparently results from the fact that the fungus spores require extremely critical conditions of humidity before they will germinate, a situation that makes it very difficult to use *Beauveria* as an effective control agent.

Against this background, we became quite excited when Survey entomologist J. V. Maddox isolated a protozoan parasite from a diseased alfalfa weevil larva collected this summer in southern Illinois. This little fellow proved to belong to a genus called *Nosema*, a member of the protozoan group called microsporidians. These parasites also produce spores. When eaten by a suscepible insect, the spores each produce a form that penetrates the lining of the gut, enters the body cavity, and there multiplies tremendously. Infection produced by this parasite is almost completely independent of the weather, so that *Nosema* has the possibility of being propagated and used as an applied control for the weevil.

To use *Nosema* effectively as a control, it would be necessary to have large quantities of the spores that could be applied to alfalfa foliage where the weevils feed. Alfalfa weevil larvae are relatively small, and it would be necessary to inoculate thousands of them to obtain enough spores for significant field trials. To get around this difficulty, Dr. Maddox tried to infect much larger insects and finally successfully infected larvae of white grubs. When the

white grubs ate *Nosema* spores, nothing happened, but when Dr. Maddox injected spore suspensions directly into the body cavity, he obtained excellent reproduction of *Nosema*. With this much larger *Nosema* "factory" now available, Dr. Maddox hopes to build up a sufficient supply of *Nosema* next spring to test the value of these little parasites as control agents for the alfalfa weevil.

Pearls, Buttons, and Pearl Seed

The ups and downs of the Illinois River clam industry have been truly remarkable. In 1872 two tons of clams were shipped from Peoria to Europe, and in 1876 another consignment went from Beardstown to New York, to be used for pearl buttons. At that time, however, the Wabash River industry was taking care of the market, and no demand arose for the Illinois product.

About 1890 clam diggers began pearling in the Illinois River, and by 1900 the pearl industry had reached considerable proportions. In 1912 a single buyer in Beardstown bought $20,000 worth of pearls in twenty days. Many of these were of excellent quality. Three matched pearls sold in Peoria for $1,100 each, and a pear pearl weighing sixty-four grains sold for $2,500. The most expensive Illinois pearl on record, from Pearl, Illinois, sold for $2,700.

The harvesting of shells for pearl buttons started up vigorously in 1907, when the demand for pearl buttons increased greatly, and soon exceeded pearling as a revenue source. The best clamming was from Chillicothe to Pearl and reached its maximum in 1909, when thousands of tons of shells sold for $12.00 to $13.00 per ton. At that time the Illinois was the most productive clam stream per mile of any North American river, supporting 2,600 boats between Peru and Grafton.

By 1920 the industry had dropped off considerably, and the advent of plastic buttons in 1940 reduced the Illinois clam industry to a low ebb.

More recently the Japanese are using the thick American shells as a source of blanks or seed for cultured pearls and are offering sixty dollars per ton for Illinois River shells. Survey aquatic biologist W. C. Starrett reports that since 1917 pollution has reduced good clamming to the lower eighty miles of the river. Working in cooperation with the U. S. Bureau of Commercial Fisheries and the Illinois Department of Conservation, Dr. Starrett is now reappraising the commercial occurrence of clams in the Illinois River with special attention to factors of pollution.

Free Trade

One of the chief problems facing scientists today is keeping up with discoveries that might advance projects under study. In spite of the tens of thousands of scientific articles published throughout the world every year, there is still nothing better than person-to-person discussion for getting fresh views and new ideas about a research program.

When researchers from laboratories in different parts of the world get together, the flow of ideas is especially effective, and none will attest this more than the Survey staff. This summer, at international conferences on bird navigation, held in Cambridge, England, and on fresh-water fisheries, at the University of Reading, England, wildlife specialist F. C. Bellrose and aquatic biologist R. W. Larimore exchanged ideas in their respective fields with fellow scientists from all over the globe.

This summer, Dr. Henry Stroyan, world renowned specialist on aphids or plant lice at Harpenden, England, brought our aphid specialists up to date on work in progress in Europe during a week-long study of our historic aphid collections.

Later Dr. John Martin of Australia and Dr. J. L. Sublette of New Mexico, both international specialists in midges, met at the Survey to study critical Survey midge collections and to integrate special worldwide midge studies involving the cooperative efforts of Dr. Martin, Dr. Sublette, the Survey's midge specialist Dr. D. W. Webb, and several specialists in Europe. Midges are becoming extremely important as indexes of degrees of pollution in both lakes and rivers, and it will be very helpful to

International scientists studying at the Survey. Left to right, Dr. W. J. Knight, Mr. R. M. Warneke, and Dr. Henry Stroyan. (Photo by Survey photographer Wilmer Zehr.)

compare the same species in different parts of the world.

During several days spent at the Survey in October, Dr. W. J. Knight, leafhopper specialist of the British Museum in London, England, discussed problems of identification of European and Illinois leafhopper species in groups common to the entire northern complex of European-North American biological communities. As these little leafhoppers become more and more implicated in the transmission of plant diseases, it is extremely important to know which are the same and which are different species in these widespread areas.

The Survey's Wildlife Research Section is host for several months to Australian wildlife specialist R. M. Warneke, who is in this country on a Harkness Fellowship of the Commonwealth Fund. On leave from his duties with the Australian government, Mr. Warneke is working closely with all members of the Wildlife Section on problems concerning the study of mammal populations. As a result, many Survey methods of studying mammal populations will soon be put to use in Australia, and certain clever techniques worked out by the Australians will be adapted to solving pertinent Illinois wildlife problems.

These personal contacts result in a marvelous free exchange of ideas and are of the greatest assistance in furthering scientific investigation.

Pheasants South

The tremendous success of pheasants in the northeastern third of Illinois, centering in the area from Champaign to Grundy County, has demonstrated the unusual ability of this bird to adapt well to a heavily farmed, cash-grain region. Below the level of Coles County, however, pheasants have never become established and are found only rarely. An early theory to explain this drop off was that summer heat destroyed pheasant embryos in the egg. During experiments centering around this theory, it was discovered that eggs of California pheasants, presumably from the hot Imperial Valley, could withstand higher temperatures than eggs of Midwestern birds, and in 1956 and 1957 large numbers of California pheasants were released in Cumberland and Wabash counties. By 1959 it was evident that these attempts to establish pheasants in southern Illinois had failed.

After these failures, it was thought that perhaps no one strain of pheasants was well adapted to this area but that, if several strains of pheasants were stocked on the same area, perhaps some of the resulting hybrid types might prove successful. A program to test this was begun in the winter of 1959-60. During this and the following three winters, Survey wildlife specialists liberated twenty-six hundred birds on twenty-five square miles of agricultural land near Neoga. The released birds included about a thousand wild Illinois birds, about three hundred wild birds from southwestern Kansas, over a thousand from California, two hundred Korean ring-neck birds, and about two hundred Japanese green pheasants. The last three

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groups were game farm birds generously provided by the Illinois Department of Conservation. The Kansas birds were caught in the field and trucked back to Illinois. The released birds were marked with back tags of distinctive colors so that the fate of the different strains could be determined.

The results, recently tabulated by project leader W. L. Anderson, contain some spark of encouragement. As Japanese and California birds virtually disappeared two to three months after being released, pheasants of these strains contributed little to the experiment. The Korean ring-necks survived well, as did the wild birds from Illinois. Kansas cocks, but not hens, also survived in good numbers. The experiment seemed to be progressing reasonably well until late summer of 1963, at which time heavy mortality occurred among pheasants in the area. The estimated breeding population the next May was only forty birds. It looked very much as if this population was rapidly on the way to extinction, the same fate as the 1956-57 releases. But in the two years since then, the situation has improved. In 1965 the estimated breeding population had risen to sixty-seven and this year it had gone even higher to ninety-five.

Wildlifer Anderson points out that it is extremely difficult to know just what is the genetic make-up of the present population. The Korean ring-neck is extremely similar to the common ring-neck represented by the wild populations of birds in Illinois and Kansas. At the moment, however, there appears to be a distinct possibility that some physiological strain may have developed at Neoga and may provide a means of extending good pheasant populations further south in Illinois.

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DECEMBER 1966, NO. 50

Tell-tale Eyes

The onion maggot poses an extremely serious threat to the large onion-growing areas of northeastern Illinois. Onions are grown on extremely high-priced land, therefore a good crop is necessary for a profit. But the onion maggot is a perennial threat. This whitish, legless larva about one-third of an inch long eats the roots and bulbs of the onions. The egg-laying adult stage is a dark fly slightly smaller than the housefly.

When abundant, onion maggots will virtually ruin entire fields of onions, therefore, their control is essential if onion growing is to be profitable. Because of the danger of insecticide residues in the onions themselves, many of the efficient chemical controls for soil insects cannot be used on the crop, but a few short-lived insecticides have been discovered that until recently gave excellent maggot control. In recent years some populations of onion maggots appear to have developed resistance to these insecticides. At the moment this is not serious, but if the resistance increases and spreads through the population, as is to be expected, the onion maggot could again become a serious economic threat.

Survey entomologists have felt that the onion maggot might be controlled and perhaps even eliminated over the entire onion growing area by the use of chemosterilants. Before these can be employed effectively, however, it is necessary to know a great deal about the life history and habits of the maggot, especially how many times the females mate and how rapidly

Adult flies of onion maggots. Normal red-eyed female at left, white-eyed male at right. Both sexes may have either eye color. Length about 3/16 inch. (Photo by Survey photgrapher Wilmer Zehr)

males and females disperse through populations in the field. Both of these questions required some means of marking flies.

The flies themselves finally provided their own marker. Onion maggot flies normally have dark maroon eyes. After the Survey laboratory culture of the onion maggot had been going for many generations, a single specimen with white eyes appeared; in the next generation another one appeared; and subsequently quite a number appeared. These white-eyed individuals were tested genetically, and it was discovered that the white-eyed individuals represented a mutant character controlled by a single genetic determinant or gene. White-eye was also recessive, that is, if both parents carried white-eye all their progeny carried it. If only one parent carried the white-eye gene, all the progeny were maroon-eyed.

Survey entomologist D. Broersma finds that this white-eye mutant provides a marker to pry into the biological habits of the flies. He is now using these naturally marked flies in mating experiments and field release trials and should soon have a great deal of basic information needed for control investigations.

Crappies for the Farm Pond

Illinois fishermen probably spend as many hours fishing for the white crappie and the black crappie as for any other type of fish. Although both species occur throughout Illinois, the black crappie is especially abundant in the clear glacial lakes of northeastern Illinois, whereas the white crappie — being more tolerant of silt — is more abundant in central and southern Illinois.

Both species reproduce in great numbers and have proven unsuccessful for stocking small ponds because they soon build up a tremendous population of stunted, starving fish. After demonstrating the potential of hybrid sunfish as a means of stocking ponds in a way that would avoid over-population and stunting (see *REPORTS* No. 37), Survey aquatic biologists thought that the same technique might be applied to the two crappies to produce controllable hybrid populations of these popular game fish. Aquatic biologist W. F. Childers had previously produced experimental hybrids between the two and discovered that first generation, the F1 hybrids, were so like the black crappie that they had been identified as this species in previous collections; the intermediate-appearing specimens belonged to the second, or F2 hybrid, generation. These discoveries made possible later identification of the generation, F1 or F2, to which field collected hybrid specimens belonged.

Several years ago Dr. Childers and Dr. Bennett stocked two farm ponds with black male x white female F1 crappie hybrids. In both ponds the F1 hybrids produced stunted populations of F2 hybrids. In one other pond the F1 crappie hybrids were stocked with smallmouth bass, with the idea that the bass would prey on the small F2 crappie hybrids. This would mean plenty of food and good growth for the bass and prevention of over-population with subsequent stunting of the crappies. The results from this experiment are extremely encouraging. Large numbers of crappie hybrids were produced, but very few hybrids of the F2 generation survived. As a result the crappie population remained well within bounds, producing good crappie fishing, and the bass thrived and produced large individuals and good fishing. Dr. Childers points out that we do not yet understand why this happens. There is a possibility that reproduction by hybrid crappies is less than that of their parent species, which would account for the small numbers of F2 individuals which survive predation by the bass. There is no good experimental evidence that this is true, therefore it is much more likely that at least members of the F2 generation have some quirk in their habits that makes them more vulnerable to predation by bass.

Further experiments are now being designed in an effort to get answers to these questions important to establishing crappies as a controllable farm pond fish.

Sweet Gum Canker

Fungus diseases of trees have a habit of popping up severely and locally in areas where they had never before been

Sweet gum trunk showing dark exudate flowing from cut-away portion at location of canker. (Photo by Dr. Neely)

observed. Mr. H. E. Brown, nursery inspector for the State Department of Agriculture, came face-to-face with this situation when a diseased condition of sweet gums appeared suddenly in the Springfield area. The symptoms of this disease are a bleeding canker, somewhat like an open sore, with a foul odor emanating from it. The exuding liquids may run down the tree trunk and cause a dark irregular stain. A similar diseased condition of sweet gums had previously been reported from New York. There it was associated with the fungus called *Botryosphaeria ribis*, and Survey plant pathologist Dan Neely consistently isolated this same fungus from diseased trees in Springfield.

Consistent isolation of the same fungus from a certain diseased condition is by no means certain evidence that the isolated fungus is actually the organism that is producing the disease. Some fungi do not attack healthy plant tissue but live in tissues already killed by another fungus or in exudates from wounds produced by another parasitic fungus. This problem arose with the sweet gum canker. Dr. Neely isolated two fungi from the Springfield specimens and the question immediately arose: Which, if either, was the causal agent producing the disease symptoms? Over the years plant pathologists have evolved a series of procedures for such logical testing and these Dr. Neely put into operation for the two sweet gum fungi.

First, wood chips from diseased trees were placed on culture plates and colonies of fungi growing from them were identified. New cultures of each kind of fungus were grown in isolation to provide a supply of each suspected pathogen for future testing. An area of a healthy sweet gum was sterilized with alcohol. Then a sterilized chisel was used to make a small artificial wound. The wound was then inoculated with one of the suspected pathogens, and Vaseline was smeared over the wound to keep out other fungi and to keep the inoculated tissues moist. One set of trees was inoculated with one pathogen, one with the other, and a third set, the check, was merely wounded. Subsequently the trees inoculated with *Botryosphaeria ribis* showed typical disease symptoms. Fungi from the diseased tissue was extracted, cultured, and identified and proved to be the same fungus as the one originally inserted into the wound. This completed the cycle of testing, and *Botryosphaeria ribis* could logically be presumed to be the causal agent of the disease.

Knowledge of the causal agent now opens up much more accurate avenues for studying the prevalence and action of the pathogen and opens the way for tests to find suitable control measures or cures for the disease.

Beetles and Pheasants

The toxic effects of many chemical pesticides on wildlife species have been well documented. However, much less is known of the ability of wild animals to regain the losses suffered from applications of pesticides to their habitats. An opportunity to study this ability arose from efforts to suppress the Japanese beetle in northeastern Iroquois County several years ago. In

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cooperation with the U.S. Department of Agriculture, the Illinois Department of Agriculture made an aerial application of aldrin, one of the chlorinated-hydrocarbon insecticides, at a rate of two pounds technical (granular) material per acre on a 12,450-acre tract near Donovan in April, 1960, and on a 29,880-acre tract near Iroquois in April, 1961.

This region is in one of Illinois' best pheasant ranges, where pheasant populations had been studied well enough to give an accurate basis for assessing the effects of these pesticide treatments on the pheasants. Survey scientists R. F. Labisky and R. W. Lutz immediately started measuring the effects of the solid-block aldrin applications.

On each treated block of farm land *at least* twenty-five percent of the adult pheasants had died by the end of May, and all of the dead pheasants that were analyzed had pesticide residues in their muscle tissues. During the ensuing summer, reproduction by surviving pheasants was severely depressed by chronic aldrin poisoning. This was shown by the meager number of chicks produced, the abnormally high proportion (fifty-four percent) of broodless hens seen during the summer, the low ratio of young per adult hen in the autumn, and the small number of males heard crowing the following spring.

During the following breeding season the reproductive gain was as high on the treated areas as on nearby untreated areas, and the pheasant populations had recovered the losses suffered from the aldrin treatment in the preceding year. Routine field observations since that time indicate that the pheasant population on these treated areas is equal to that of the surrounding countryside.

Wildlifer Labrisky points out that such a rapid recovery of these pheasant flocks was accelerated by two factors. First, the areas treated were relatively small, which permitted ready colonization of the area by pheasants from adjacent untreated land. Second, the pheasant populations in the general region were increasing in abundance before, during, and following the years of treatment. He points out further that pheasant populations in Illinois have decreased considerably in the last few years and that under these conditions of lower populations, the recovery of pheasants in heavily treated areas such as the Iroquois County tracts would undoubtedly be much slower, perhaps prolonged over several years.

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JANUARY 1967, NO. 51

Bread-and-Butter Duck

In the minds of Illinois duck hunters, no bird compares with the mallard. It comprises the bulk of the annual bag, responds well to duck calls and decoys, and is a large tasty bird. It is indeed the bread-and-butter species of Illinois duck hunting. Because of its importance, in 1939, Survey wildlife specialist F. C. Bellrose began making fall censuses of mallards migrating through the Illinois and Mississippi valleys. The figures for the last 20 years indicate peaks for 1949 and 1955, generally low populations from 1958 to 1966, and a most discouraging low in 1961.

To get some understanding as to what factors might be causing these ups and downs, wildlifer Bellrose gathered information concerning, first, the ratio of adult and juvenile ducks in each year's migratory flight and, second, conditions in the prairie pothole country to the north and west where the mallards breed. His long term study of these factors disclosed a fairly close parallel between the density of ponds in Manitoba and Saskatchewan and the success of the breeding season as measured by the proportion of juvenile mallards found in the bag of Illinois hunters. On this basis, breeding success has been low since 1955, except for the 1960 and 1965 seasons. The better breeding success in 1960 was not enough to bring the population up in the face of continued dry conditions on the breeding grounds.

The increase in mallard productivity in 1965, combined with favorable water conditions over much of the mallards' breeding grounds in the spring of 1966, resulted in the most successful Illinois hunting season for practically a decade. Duck clubs along the Illinois River report an increase in success ranging from 20 to 50 percent and other sources in the upper Mississippi Flyway indicate an increase of 40 percent over 1965.

Because of the greater numbers of mallards in 1966, hunters are inclined to be optimistic about mallard prospects in 1967. Wildlifer Bellrose warns, however,

Average number of mallards present per week during the fall migration in the Illinois and Mississippi valleys, from 1946 to 1966. (Figures compiled by F. C. Bellrose.)

that all the signs are not rosy. Although a satisfactory breeding population should return to the plains of the Dakotas and Saskatchewan in the spring of 1967, the dry, late summer and fall of 1966 may have reduced the supply of surface water on the breeding grounds. Waterfowl enthusiasts can only hope for heavy snows and a rapid spring runoff, which would improve the abundance and condition of small water areas in the northern Great Plains prior to the 1967 mallard breeding season.

Custom Spray Operators

This month the Illinois Natural History Survey and the University of Illinois College of Agriculture present their nineteenth joint training school for custom spray operators. The school is to be held January 24-26 in the Illini Union Building.

This annual school, developed over the years to acquaint Illinoisans with spraying problems and practices pertinent to the state's agriculture, has become a favorite with pesticide dealers and salesmen, both ground and aerial custom applicators, farm managers, farmers, seed corn growers, canners, farm advisors, and the press. Survey and University entomologist H. B. Petty, who has been one of the mainsprings of the school from its inception, notes that the first school, held in 1948, attracted an attendance of 350. In a few years the number dropped to 225, but since then the school has drawn increasingly large audiences, the eighteenth having an audience of 1234.

The nineteenth school will emphasize control of plant diseases, weeds, and insects, chiefly in relation to field crops but with some attention being given to turf, lawn, ornamentals, and livestock problems. Twenty-seven speakers will cover 39 topics. The fast, hard-hitting program features 15-minute topics. Each speaker abstracts the salient points of his talk, and these are available at registration. Most of the speakers are from the Survey and the University, but several are from other states. The latter come here to share their experiences and problems that have a bearing on the Illinois scene.

Special entomological topics this year include reports on pesticide residue studies, drift control, and personal hazards to applicator personnel, plus latest information on three insects of mounting economic importance in Illinois — corn leaf aphids, resistant strains of corn rootworms, and the alfalfa weevil.

Carlisle Reservoir

When Carlisle Reservoir started filling on August 16, 1965, sportsmen and fisheries biologists were extremely curious about the effect the lake would have on fishing in the Kaskaskia River. After a year and a half the results are now coming in. Survey aquatic biologists R. W. Larimore and D. L. Thomas, using their detailed fish censuses for six pre-impoundment years, are studying the changes in numbers and growth rates of the fishes above, below, and in the lake, and Arnold Fritz of the Department of Conservation is making a complementary creel census to ascertain what fish are being caught.

Flooding the rich bottomlands now comprising the reservoir triggered a tremendous production of organisms valuable as fish food — tiny animals called zooplankton, insect larvae, and the young of such fish as shiners and gizzard shad. This surfeit of fish food abounded in the lake and overflowed into the river below the dam. As a result the growth rate of fish increased greatly, with a resulting larger number of plump, desirable fish. The largest increase of these was in the river immediately below the dam where good-sized white crappie, largemouth bass, gar, carp, and drum are abundant.

Several fish new for the area are beginning to appear, notably walleye pike, sauger, and black buffalo. These are giving an occasional fisherman a great thrill. If they become established, these and other species will contribute substantially to the sport fishing of the area.

As a result of this upsurge in fish growth and variety, fishermen are flocking to the Carlisle Reservoir tailwaters from as far away as East St. Louis and are happy with their success.

The filmy fern. *Above,* typical habitat in Jackson Hollow; one of the figures points to the shady base of the undercut where the ferns grow. *Lower left,* delicate fronds of the fern or sporophyte; fronds range from 2-6 inches long. *Lower right,* a mass of tiny moss-like gametophytes. (Photos by former Survey photographer W. E. Clark.)

The Filmy Fern

One of the botanical gems of rugged southern Illinois is the filmy fern, a perennial evergreen plant with slender, creeping, wirelike rootstocks and fronds or leaves that have light green translucent blades only one cell thick. This delicate fern has a highly restricted habitat, almost all of its colonies occurring on moist, shaded vertical faces at the bases of sandstone overhangs.

In the earlier plant explorations of North America, this fern was thought to occur in the Appalachians from Alabama to West Virginia and Ohio, with more western localities in Tennessee and Kentucky. In 1921 Miss Helen M. Strong, of the University of Chicago, found it in Bethell Hollow, Pope County, Illinois; two years later Dr. Mary M. Steagall of Southern Illinois University collected the fern in Jackson Hollow about a mile away.

Thirty-four years later Survey botanist R. A. Evers discovered another Illinois colony at Hayes Creek Canyon north of Eddyville, also in Pope County, and subsequently brought the total number of Illinois localities to eleven, all in Pope and Johnson Counties. In each locality the ferns were growing far back at the base of sandstone undercuts where they were completely shaded except for one or two spots that received a few hours of sunlight when the sun was at its lowest during the shortest days of winter.

Ferns have an interesting life history. The fern-like form produces spores and is therefore called the sporophyte generation. The spores germinate into minute little

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plants called the gametophyte generation that form the sexual cells or gametes. A fertilized female gamete grows into a fern-like sporophyte. Until recently records of filmy fern were all based on the typical fern or sporophyte generation. Recently Dr. Evers and Dr. W. H. Wagner, famous fern specialist of the University of Michigan, made a careful study of the Illinois filmy fern beds and discovered the gametophytes which appeared like thin sheets of fine dense moss. Subsequent search disclosed that beds of these minute gametophytes occurred also in Union, Hardin, and Gallatin counties, but, for some reason, the sporophyte had not developed in these areas.

Dr. Evers points out that the Illinois colonies of this fern could well be endangered by lake development projects, because the filmy ferns grow only at the extreme bases of the bluffs, which would be the first area to be flooded if valley waters were impounded.

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Pine Problems

Increase in needle blight disease of pines, caused by the fungus *Dothistroma pini,* is proving to be quite a headache for landscapers using pines as ornamentals or in windbreaks. The disease causes severe defoliation, which results in weakening of the trees, die-back of branches, and frequently the death of the tree. Even if the tree is not killed, it may be unsightly during a good part of the growing season.

Dothistroma needle blight is widespread in the United States and has been reported from Britain, Canada, Chili, and Kenya. In the Midwest it affects especially Austrian, ponderosa, and Japanese black, favorite pine species for ornamental plantings.

Fortunately, needle blight disease is not a pest of forest plantings, so that it is not a threat to pine plantations being managed for marketable timber. Survey plant pathologist D. F. Schoeneweiss notes also that the disease has not yet shown up on Christmas tree plantings which are predominantly Scotch pine, so far apparently immune to the disease.

In late summer the fungus produces slightly swollen, light-colored bands on one-year-old and older needles. On some pines the bands become red — a condition referred to as "red-banding." The following March the fungus grows in the swollen areas and by May produces dark brown to black raised fruiting bodies visible through cracks in the needles. Spores produced in these fruiting bodies are liberated during the growing season and cause new infections.

In other states, applications of various fungicides have been suggested to control needle blight, but Dr. Schoeneweiss finds that these do not give satisfactory results under field conditions in Illinois. A search is now in progress for treatments or practices that will reduce infection and defoliation.

Bird Botanists?

The problem of designing ultrasmall radio transmitters for attachment to song birds continues to be one of the Survey's foremost concerns. If these devices can be attached to birds, the birds can then be released and their movements followed for various lengths of time. Survey wildlife specialist W. W. Cochran devised a tiny

Needles of Austrian pine showing symptoms of needle blight disease. (Photo by Dr. Schoeneweiss.)

transmitter that could be glued to a back tag and which is then tied to a bird. The total mechanism weighs only 5.7 grams.

Last summer his Survey colleagues, R. R. Graber and S. L. Wunderle, tested this transmitter on a robin which they were able to follow night and day for two full days. Notes were kept as to the exact trees frequented by the robin, what it did in each, and its movements from tree to tree. They discovered, first, that even during the day the robin spent two-thirds of its time sleeping or resting with its eyes closed and only a quarter of the day foraging and feeding. At the end of the day it moved to a high perch for the night.

On looking over their notes, Dr. Graber realized that the robin had settled in only a few of the many trees present in the area and he and Wunderle then tabulated all the trees in the area and the percentage of the day that the robin spent in each species of tree. This tabulation brought out the interesting realization that the robin fed chiefly in hackberry and black cherry but did a great deal of resting in Scotch pine and silver maple. Even though other species of pines and maples were present and other species such as elm, ash, linden, and oak offered trees that superficially seemed to be just as good resting areas, these were not visited by the robin.

Is this selection by the robin of certain tree species the result of an accidental habit that it follows day after day, or is the robin indeed a good botanist that can tell one species of tree from another?

Microsporidian Bank

Some of the most effective parasites of insects are microsporidians, microscopic one-celled animals about 1/50,000 of an inch long. If some of these get into the body cavity of a susceptible insect host, they multiply prodigiously and eventually kill the insect. At this time the microsporidians change into a spore stage, and it is these spores that infect other insects.

In spite of the pathogenic potential of these microsporidians, surprisingly little is known about them. This lack of information is due in part to the time-consuming techniques needed to study and identify the different kinds and partly to the difficulties of keeping the right kind of living insects for propagation of the parasites.

In this situation, it would be highly advantageous to be able to use information published by scientists in all parts of the world, but this has proven extremely difficult. In many instances the researchers neither preserved materials nor described organisms sufficiently to indicate for certain what they had. In other instances, characters observable only in living cultures are needed for identification and only a few dead specimens on microscope slides are available for study.

To overcome these difficulties in the future, Survey entomologist J. V. Maddox, our expert with these tiny creatures, envisaged a microsporidian bank in which cultures of different species from all over the world could be preserved alive for future culturing, comparison, and propagative stocks for insect-control programs. The idea was enthusiastically received by interested entomologists so that all that remained was to get the bank in operation.

Here Dr. Maddox ran into serious problems. He estimated that if microsporidian spores could be kept alive for at least five years, it would be simple to set up a rearing program for the correct insect hosts and renew the microsporidian cultures every five years. He had already kept army worm microsporidian spores for two and one-half years, with best results in a water suspension. When he tested other microsporidians, however, the situation proved difficult. The species infesting flower beetles proved to require dry conditions for spore survival; if the spores got wet, they died. Other species, including the one infecting the alfalfa weevil, seemed to have all the short-lived spores and for these two months has been the best survival time achieved yet.

Preliminary experiments with freeze-drying have given some promise of a method of preservation that will increase the longevity of these normally short-lived spores and new, more sophisticated equipment is on the way to test various freeze-drying techniques to see if they may lead to a successful storage technique. When

The Survey laboratory on the banks of Ridge Lake, the scene of 25 years of fisheries research. (Photo by former Survey photographer W. E. Clark.)

such a technique is found, the Survey can really start its microsporidian bank.

In discussing these problems, Dr. Maddox pointed out that efforts to solve storage problems for the bank have led into one of the most important problems to be solved for the use of microsporidians for insect control. These microsporidians have never yet been cultured and all of them need live hosts or tissue cultures to grow. This has made it extremely difficult to keep on hand large enough quantities of microsporidian spores to spray more than a small test plot of insects. If some sure method of long-range storage could be achieved, it would be possible to stock-pile large quantities of the parasites and have them instantly available for field application.

Fishery Concepts

Twenty-five years ago Ridge Lake, situated eight miles south of Charleston, Illinois, in Fox Ridge State Park was a typical small-valley impoundment typical of many that could be constructed in Illinois. Survey aquatic biologist G. W. Bennett and his colleagues have used this as an experimental lake since then with the idea of devising ways and means of producing the best possible sport fishing. Controlled fishing and creel censuses gave an accurate picture every year of fishing success, and periodic censuses, combined with complete drainage of the lake, at various times gave accurate information concerning the number of fish in the lake, their size, age, and growth rate.

Many problems remain to be solved but some solid base lines have been established:

- After its first flush of high carrying capacity due to the rotting bottom vegetation when the lake was initially flooded, the carrying capacity of Ridge Lake has remained relatively static. Two factors contribute to the carrying capacity: first, the minute green plants that utilize sunshine falling on the lake and produce the "crop" of living food, and, second, soil or vegetation washing into the lake from the surrounding terrain. The latter is negligible in Ridge Lake, hence its basic inventory of foodstuffs comes almost entirely from the green plants, large and small, growing in the water.
- The once fertile bottom of the lake is gradually being silted over with the infertile clay soil, and this will gradually make the lake even more dependent on the plant life generated within the lake itself.

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• Without some means of control, the number of bluegills and bass normally increase to the point that usually within three, and certainly within four, years the lake would have a population of huge numbers of small, stunted fish.

• Using a regular program of population control, including a combination of drawdowns with occasional draining and culling, the total number of fish can be reduced, with a resulting increase in the number of large fish and therefore greater fishing success.

• Theoretically an increase in food (in the form of abundant small fish) for bass should result in vigorous growth and therefore many large bass. No such correlation was found. The obvious answer seems to be that, contrary to current opinion, bluegills are not a preferred food of bass and may be eaten only when the bass are very hungry. This relationship undoubtedly explains why the smallest poundages of bass were associated with the largest poundages of bluegills, and vice versa. The inverse ratio indicated by these figures suggests that bass and bluegills are at least to some extent competitors for the same food, rather than having a strict prey-predator relationship.

The bass-bluegill combination has been almost the traditional one throughout the warmer waters of the Midwest south of the cooler trout-water country. In reviewing these results at Ridge Lake, this combination is appearing to have severe limitations, at least as applied to Illinois, and other techniques of management are badly needed to improve sport fishing in the state. The Survey's programs of developing hybrid fish and testing a wide variety of lake fertilizers, at present being tested on smaller ponds, may contain some of the needed answers for improving lake fishing.

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MARCH 1967, NO. 53

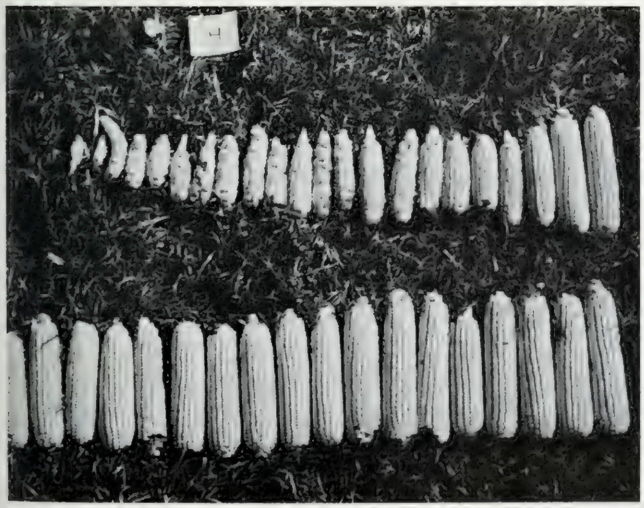
Insidious Guest

One of the common sights in midsummer cornfields is a colony of small, dark aphids or plant lice on leaves or tassels of corn plants. Each corn leaf aphid is about one-tenth of an inch long and feeds by inserting a needle-like sucking apparatus into the plant and pumping out the plant juices. Little has been known about this particular aphid. It infests cornfields through mid-season, then disappears, and produces little visible damage to its host plants.

What seemed to be an increase in populations of this aphid in the last few years caused Survey entomologists to wonder how much damage these little insects actually did. To determine the maximum losses that might be caused, entomologist Roscoe Randell selected 22 cornfields in different areas of central and northern Illinois and in each tagged 100 heavily infested corn plants and 100 uninfested plants. Each of the uninfested plants was located near a heavily infested one. When harvest time came, he found a tremendous difference between the two sets of plants.

The 2200 heavily infested plants produced 54 percent less corn than the 2200 clean plants. Expressed in ears of corn, the clean plants produced 84 percent good ears and 15 percent nubbins; one percent of the plants had no ears. The infested plants averaged 36 percent good ears and 30 percent nubbins; 34 percent of the plants had no ears.

Results differed greatly from field to field. In one field, the heavily infested plants showed a reduction of 80 percent, in another field, only 12 percent. This variation appeared to be correlated with several other factors affecting yields. Where weeds were abundant, competing with the corn for soil moisture, and where



Total ears from two complementary aphid test plots. *Above,* from heavily infested corn plants; *below,* from corn plants almost completely free of aphids. (Photo by Petty and Randell.)

rainfall was lower, the aphids apparently took a greater toll of plant nutrients. Under these conditions it would appear that the aphids extracted their share first and the corn plant had to get by on what was left.

Figures were run on aphid infestations throughout the 22 fields. Out of every 100 corn plants, an average of 18 were heavily infested with aphids. This figure, combined with the average lower yield of the heavily infested plants, indicates an overall yield reduction of 9.7 percent. This is a conservative figure because it does not take into account yield reduction caused by light to moderate infestations, for which no allowance was made in these counts.

With the knowledge that the corn leaf aphid could be a serious pest, comes the realization that we know very little about its habits. In June and July the corn leaf aphid population builds up on grasses, especially foxtail, and migrates to corn beginning in early July. Populations on corn increase until about August 1, remain constant in number for two or three weeks, and then disappear by the end of the month. Where they spend the rest of the year and in what stage is still a mystery, although such knowledge might be extremely useful in devising control methods. Investigations of this unknown part of the life cycle are next in order.

Log Life

Last year, when Survey aquatic biologist R. W. Larimore discovered the tremendous amount of small insects and other aquatic organisms that drifted down the Kaskaskia River at night, the question arose: "Where do they come from?" Preliminary sampling disclosed that parts of the river with a mud and sandy bottom produced too few organisms to account for the large quantity found in the drift samples *(INHS Reports 40)*.

Further sleuthing was delegated to Dr. Larimore's colleague H. C. Nilsen. Knowing that fishermen often favor brush piles in the river, he first examined submerged logs and discovered that they had a remarkably extensive fauna of minute plants and animals. This led to questions as to how long it took this fauna to become established on submerged logs.

To find this out, biologist Nilsen fastened log sections on the bottom of a sandy stretch of the river near Sullivan. His main experiment consisted of 30 of these logs anchored horizontally, parallel to the current, in water normally about 2½ feet deep. He removed five logs each week and examined the aquatic life established on them. His experiment, performed last fall, is providing a remarkable insight into a poorly-known phase of aquatic biology.

At the end of the first week, a moderate number of small midge larvae and aquatic worms were found on the logs, plus a slight growth of algae (minute single-celled green plants). In succeeding weeks, the algae increased considerably, providing an abundance of green plant material on which animals could feed. As the algae increased, so did both the number and the diversity of animals. By the end of the six-weeks experiment, the algae were abundant and the animals formed an abundant and complex living cosmos of aquatic worms, water mites, many types of water fleas, and larvae of many kinds of insects.

When the Nilsen adding machine finally tabulates this intricate fauna, it will give us a new perspective on the production of fish food in sluggish streams and reservoirs.

Island Chlorosis of Hackberry

The search for graceful boulevard and yard trees in the wake of elm decimation in Illinois has focused attention on ailments of other trees that were not considered noteworthy before. One of these is island chlorosis of hackberry. This disease develops as isolated yellow or cream-colored areas on leaves produced during the middle of the growing season. The first symptoms appear in late June or July and continue during the remainder of the growing season. The island-like areas are bordered by small veins or veinlets and are variable in shape, ranging from square to rectangular to triangular. Coalesced areas

Applying tag to a cottontail rabbit prior to its release into the observation enclosure. (Photo by Survey photographer Wilmer Zehr.)

are irregular in shape and may eventually embrace the entire leaf.

Reported originally in Lansing, Michigan, in 1939, this disease was first observed in Illinois in 1944. It is now common and widespread on American hackberry. Survey plant pathologist J. C. Carter reports that last year many Illinois trees were so badly affected that the entire tree had an unslightly yellow appearance.

The cause of this disease has not yet been determined. The chlorotic appearance is somewhat similar to that caused by nutritional tree disorders, so Dr. Carter injected chlorotic trees with iron sulphate, then sprayed them with copper, zinc, and manganese compounds containing traces of numerous other minor elements, a frequent cure for chlorosis. These sprays produced no discernible results.

The next best guess for this kind of plant disorder is that it is caused by a virus transmitted from tree to tree by leafhoppers. Checking on this angle, Dr. Carter discovered that the hackberry trees were infested with the potato leafhopper, *Empoasca fabae*. In a limited series of tests performed by Survey entomologist L. L. English, various trees were sprayed with DDT to eliminate the leafhopper, and other individual branches of unsprayed trees were caged to prevent leafhopper feeding. Foliage protected from leafhopper feeding by either method showed no or slight scattered chlorosis, indicating that the leafhopper was involved.

Now another problem arises. *Empoasca fabae* is a curious leafhopper that has never been incriminated with the transmission of a plant virus. When feeding, however, it injects into the plant a salivary compound that is extremely toxic to certain species of plants, producing a shriveling and browning called hopper-burn on potatoes and garden beans. The question now is whether or not island chlorosis of hackberry is caused by a virus transmitted by the potato leafhopper or whether hackberry is another plant that has this peculiar sensitivity to the potato leafhopper's saliva.

Rabbit Nests

During spring and summer, doe cottontails in Illinois give birth to litters of young roughly every 28 days. The first litter is usually born in late April with one a month through August, plus an occasional litter in September and, rarely, one in October. A doe prepares a separate nest each time she has a litter. The details of this nest making have been poorly understood.

To obtain accurate information on this nest-making activity, former Survey wildlife researcher D. A. Casteel studied cottontails in a two-acre tract enclosed by a rabbit-proof fence and surrounded by an electric fence to keep out predators. A 2½ foot square platform was set 25 feet above the ground on a utility pole, the platform surrounded by a guard rail draped with burlap screening to form a blind. Three feet below the platform were mounted five 150-watt adjustable floodlights that could be turned on or off from the platform. Cottontail rabbits were trapped, marked with colored flexible ear tags, and released in the pens. Various parts of the enclosure were mowed in order to increase the visibility of particular areas. Cottontail nests were located by searching the pens on foot and scanning

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them with binoculars. Once nests had been located, observations were made from the elevated platform. Four nests were observed throughout their construction, 17 additional ones during certain phases of construction.

Wildlifer Casteel found that the nests were started only a few days before the doe gave birth to the litter. The first step was the excavation of a hole roughly four inches deep, five inches wide, and six inches long. The doe dug the hole using forefeet and chin to loosen and remove the dirt, occasionally biting extra hard bits of soil to break them up. The hind feet were not used in digging.

The next step consisted in lining the cavity with dry vegetation, primarily grasses and other herbs gathered in the vicinity of the nest. The doe carried sheaves of vegetation crosswise in her mouth, with stalks extending several inches on each side. After returning to the nest with a load of this hay, she inserted her head into the hole and arranged the material with head and forefeet.

The final nest-making stage was lining the cavity with fur. By the time the fur-lining stage was reached, the doe was usually only a few hours from delivery. She pulled hair from her shoulders, flanks, back, legs, and even feet, but not from the abdomen. After several minutes of fur pulling, the doe took the accumulated hair to the nest and arranged it, then retired ten feet or so away and resumed pulling. Usually by the time the fur lining was complete the doe sat on the nest and started giving birth to her five or six young.

It was found that during at least the first nest construction, the fur was chiefly hair in the process of being molted. The nature of the doe's hair during later nest-making episodes, and how rapidly it grows back after nest-making, is not yet known.

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APRIL 1967 NO. 34

For Chrysanthemum Lovers

One of the most unwelcome and annoying problems encountered in the growing of chrysanthemums indoors, both in the greenhouse and the home, is the control of tiny animals called two-spotted mites. These mites, barely visible to the naked eye, are so small that one can hardly believe they could be so destructive. They are usually found on the under sides of leaves, where they feed by piercing the leaf cells with their needle-like mouthparts and sucking out the cell contents. Heavily infested chrysanthemum plants are stunted, the leaves bronzed, and the flower petals frequently matted together with tiny webs that may gradually festoon the entire plant.

Although tiny, these spider mites build up large populations with great rapidity. The female mites lay eggs on the leaf surface, spinning a few strands of silk over them, and the eggs hatch in less than a week. As a result, the mite population increases about 15 fold every week, and in just a few weeks can reach astronomical proportions.

To date, control measures for spider mites have included chemical fumigants, fogging, and sprays. Several of these methods are quite effective, but the inhalation of these chemicals during application is hazardous to the operator, and some of the sprays leave an unsightly spotted residue on the leaves. These methods are especially difficult to apply to chrysanthemums in the home, hence infested plants in the home usually have to be discarded.

In trying to find a safer and more convenient control method for spider mites, Survey entomologist J. E. Appleby decided to try some of the systemic poisons that have proven highly successful for insects such as the iris borer. He therefore used certain systemic poisons applied to the soil in which the chrysanthemums were growing. The chemicals were absorbed by the plant roots, carried upward in the plant sap to the leaves and flowers, and ingested by mites feeding on the plant juices. Some of the systemic compounds were applied as liquids poured on the soil, others, as granules sprinkled on top and worked into the soil surface. Although these experiments are still in their early stages, Dr. Appleby reports excellent initial success. Several of the compounds killed the mites and re-

A chrysanthemum blossom shows festoons of webs made by the two-spotted mite. The little white dots in the webs are the full grown mites. (Photo by Survey photographer Wilmer Zehr.)

duced the infestations rapidly. But there is still one obstacle. Certain varieties of chysanthemums are slightly injured by the treatments, and additional research is now being planned to solve this problem. It seems certain, however, that an efficient and easy-to-apply remedy will soon be forthcoming for spider mites on chrysanthemums.

Open-water Bluegills

Bluegills have usually been considered denizens of well-aerated shore waters with abundant rooted aquatic vegetation such as foxtail and pondweed. In order to get a quantitative measure of this preference, Survey aquatic biologist D. F. Hansen suspended trot lines from floats over various depths in Lake Glendale, fitting each line with baited hooks a foot apart. It was evident from his results that bluegills were not only present but abundant in the open areas of the lake. Here they were most numerous in the depth range of 8 to 16 feet, with moderate numbers present in the bottom levels from 17 to 20 feet. In this deeper water the oxygen content was less than 1 part per million. This unexpected discovery led to many questions concerning the food and movements of the bluegills.

To check on the food, stomach contents were examined of 200 bluegills taken in the open water. These contained primarily midge larvae and pupae and animal plankton, the latter including chiefly the tiny water fleas called *Daphnia*, but many stomachs contained food items such as leaves of rooted aquatic plants, dragonflies, caddisflies, and snails that occurred only around the edges of the lake. This indicated a movement of bluegills between the lake margins and the open water. The midge larvae and plankton items might also have been eaten in the marginal areas, raising the possibility that the bluegills were moving into the deeper open water simply to enjoy the cooler temperatures, and might not be feeding there.

When the food items of the open-water fishes were tabulated with respect to the depth at which the fish were caught, a most interesting correlation was found. The fish caught at depths from 5 to 16 feet had eaten primarily animal plankton, but the fish caught at 17 to 20 feet had eaten primarily midge larvae, including large and small kinds. Next, bottom samples were taken at different depths in the lake, from the margins to the deepest parts, and examined for food items. In these samples, midge larvae were the predominant animals present and again the two sizes were encountered. The Survey's midge specialist D. W. Webb identified these as two separate species, not just early and late stages of the same species. When this distinction was translated to the collections, it was found that the larger species occurred only in the deepest water of the lake, at a depth of 19 to 20 feet, and that the smaller species, although more abundant in off-shore samples, occurred also in the weed beds along the shore. From this it is obvious that the bluegills caught at the 17- to 20-foot depths were securing most of their food from the midge population growing on the bottom.

The present results explain why shore fishing for bluegills is always better in fall, winter, and early spring than in summer, but, as Dr. Hansen points out, raise many questions that need to be answered about the movements of bluegills in a body of water such as Lake Glendale. The peculiar success of surface fly fishing along the shore in summer for only a short period just before dark is suggestive that there may be a rhythmic movement of bluegills between deep water and shore at this time. Because of the difficulty of following the movements of individual fish in a lake, novel methods of investigation may be needed to understand these phenomena better.

Tick and Chigger Warning

Hikers and outdoor enthusiasts should again be on the lookout for ticks and take precautions against chiggers.

In Illinois two kinds of ticks may attack humans. The wood tick begins its activity in Southern Illinois in late February and in the North in May, becoming common in April, May, and June. Usually they are all gone by late July. The lone star tick comes out later, and is more abundant in August.

Survey entomologist L. J. Stannard

The bluegill, abundant in most Illinois ponds and lakes, and favorite of many anglers. (Photo by Dr. G. W. Bennett.)

points out that these two ticks differ greatly in their habits. The adult is the only stage of the wood tick that bites humans. It normally inflicts little pain but is an effective carrier of the virus that produces spotted fever, which may be fatal. All stages of the lone star tick bite humans. They inflict painful bites but are very seldom transmitters of disease organisms.

Chiggers may be encountered from mid-May to September. They transmit no disease organisms to humans, but their bite causes painful itching.

More information on these species, including diagnostic notes, likely places where they may be encountered, preventative measures, and information concerning the treatment of their effects may be obtained by writing to the Survey for Dr. Stannard's new leaflet *Ticks and Chiggers.*

Planned Parenthood for Pigeons

In many Illinois communities semiwild pigeon populations are increasing rapidly and becoming both a nuisance and a hazard. Around homes their messy nests are unsightly, and around the farm pigeons eat a surprising amount of livestock feed. The pigeon is one of the birds that can carry the virus causing psittacosis or parrot fever, an infectious disease that occasionally gets into humans and produces pneumonia-like symptoms. Most people contract the disease by actually handling birds, but as pigeons increase around domestic situations there is an increased hazard of indirect infection. Recognizing these problems, in 1966 the University of Illinois Health Service sought the help of the Natural History Survey in finding some means of curbing the campus pigeon population.

In checking on this problem, Survey wildlife specialist R. R. Graber found that pigeon control programs using poisons such as strychnine not only presented many hazards, but at best their effects were temporary. Pigeons may produce two or more broods a year, and it is the high populations of late summer and fall that are of special concern. Dr. Graber learned that in laboratory studies at the University of Missouri certain antifertility compounds, particularly hypocholesterolemic agents, had shown great promise in blocking reproduction in pigeons, although these materials had not been tested in natural situations with free-living birds. He therefore suggested that a program using these compounds be initiated on the campus to test their effect on town populations of pigeons.

Preliminary to the actual testing of the antifertility compounds, it was essential to learn the areas of activity of individual birds and to determine where the birds nested in relation to where they fed. To get this information, Dr. Graber trapped pigeons on the University hospital roof, attached minute radio transmitters to them, and tracked them for several days in late March and early April. He found that the area of activity of these pigeons was very restricted. If food (corn) was kept available on the hospital roof, the birds spent 85

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percent of their time within half a block of the hospital. Their night roosts and their nests were on the hospital itself. The situation was thus ideal for testing the antifertility compound.

An experimental antifertility compound provided by Searle Chemical Company was mixed with corn at a dosage level of 1 part per thousand, and this was spread on the hospital roof and eaten by the pigeons. Mr. Gale A. Fella, University Sanitarian, continued the study through the summer, providing treated grain for the birds and observing their nesting activities. Under these field conditions it was impossible to determine the dosage levels of the antifertility compounds per individual bird, but the results of the treatment were gratifying. The birds nested normally, laid at least some eggs, and incubated the nest for about 2½ weeks. However, no young were produced by the hospital pigeon population during the 1966 breeding season. These observations provided grounds for optimism that urban pigeon populations can be controlled by an intensive use of this method.

Dr. Graber points out that this optimism is based on the fact that these wild city pigeons are still essentially captives because of their close attachment to man and their reliance on man for food. In an urban setting the low availability of food greatly facilitates the chemical treatment of pigeon population. Before the method can be widely used, however, it will be necessary to work out precautions that must be observed to safeguard humans, livestock, and pets.

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MAY 1967, NO. 55

Gladiolus Virus Problems

In their study on virus diseases of gladiolus, Survey plant pathologists J. L. Forsberg and Walter Hartstirn have been giving special attention to how the virus diseases spread. It is known that different species of aphids may transmit some viruses from plant to plant, but this may be sporadic rather than usual. Once a plant is infested with a virus, it persists in the corm year after year, and when corms divide the daughter corms are also infected. Some investigators have believed, however, that viruses are seldom transmitted through cormels.

Because gladiolus plants do not breed true, varieties cannot be propagated by seed. Such propagation is used only to develop new varieties. Standard varieties are propagated entirely vegetatively. During the year the growing plant produces a new corm which may subdivide in the process. It also produces numbers of small bulblets called cormels at the base of the corm, and these are generally the most important method of propagation used by commercial gladiolus growers. Each cormel, when planted, will develop into a corm that will produce a flower the second year. Some varieties produce only a few cormels on each corm but others may produce a hundred or more per plant.

Because previous experiments testing transmission of virus disease through the cormels were based on only a few specimens, Drs. Forsberg and Hartstirn decided to run a large experiment that would give conclusive evidence concerning how much virus disease is transmitted through the cormels from infected plants. First they tagged plants which had shown symptoms of the white break virus disease for the past two summers. Each plant was assigned a number and its corm and cormels saved for further study. About 10,000 cormels from these tagged plants were planted in the greenhouse and the developing plants are being observed for virus symptoms. To avoid wasting greenhouse space, the cormels were germinated in the laboratory and the duds discarded. The developing

Gladiolus corms with small cormels growing out of the bottom of the corms. Some corms produce more than a hundred cormels. (Photo by Dr. Creager, formerly of the Illinois Natural History Survey.)

plants in the greenhouse will produce only leaves this year, but should flower next.

Although it is too early to draw definite conclusions, the two pathologists have already observed virus symptoms on leaves on many of the developing plants. This is highly suggestive that the transmission of viruses through cormels is much more extensive than has been reported and that other means of virus control must be sought.

Always Hungry

The animals always ready to "dine" with us are the insects. Some of them, such as picnic beetles and flies, are highly social and join us at the table. The vast majority we seldom see. These are the caterpillars, beetles, aphids, grasshoppers, weevils, and many others that feed on our agricultural crops growing in the field.

Uncontrolled, the various species of insects can be expected to reduce yields on an average of about 10 percent; under high population conditions they can destroy 90 to 100 percent of particular crops in particular localities. In different years, different insects will be the main culprits. In 1965, for example, the potato leafhopper and the pea aphid were by far the worst pests of clover and alfalfa in Illinois; they were negligible in 1966, when the alfalfa webworm, grasshoppers, and the alfalfa weevil were the main defoliators.

In order to keep losses to a minimum, Illinois farmers follow tight insect control programs based on advice sent out cooperatively each week by the Natural History Survey and the University of Illinois College of Agriculture. Survey entomologists Stevenson Moore III, Roscoe Randell, and Donald Kuhlman have been gathering figures on the results of these control treatments. They report that in 1966 insecticides were applied to over 6,000,000 acres, with a total estimated profit of about $29,600,000, over and above treatment costs. In 1965, 5,600,000 acres were treated, with a profit of over $27,500,000.

Commenting on these figures, Survey entomologists W. H. Luckmann notes that from 1964 to 1966 there was a 20 percent

Acres of Field Crops Treated with Insecticides and Estimated Profit from Treatment, Illinois, 1966

Crop and Insect	*Acres Treated*	*Estimated Profits**
Corn		
Armyworms	16,138	$ 24,207
Chinch bug	2,443	14,658
Corn flea beetle	5,117	25,585
Corn leaf aphid	79,649	398,245
Cutworm	122,521	735,126
European corn borer	49,400	172,900
Grasshoppers	11,177	11,177
Soil insects	5,443,197	27,215,985
Soybeans		
Alfalfa webworm	7,750	27,125
Bean leaf beetle	2,891	11,564
Grasshoppers	6,488	19,464
Green cloverworm	81,433	285,015
Mites	4,132	6,198
General		
Chinch bug	1,825	5,475
True armyworm	111,916	447,664
Grasshoppers	22,483	67,449
Clover and alfalfa		
Alfalfa webworm	12,017	72,102
Alfalfa weevil	10,372	20,744
Clover leaf weevil	3,101	4,652
Grasshoppers	11,909	17,864
Meadow spittlebug	220	330
Pea aphid	293	586
Potato leafhopper	4,548	9,096
Variegated cutworm	63	126
1966 Total	6,011,083	$29,593,337
1965 Total	5,589,583	$27,659,463

* Over and above treatment costs.

increase in number of acres treated with chlorinated hydrocarbon soil insecticides, but a 75 percent increase in acres treated with organophosphorus soil insecticides. This disproportionate increase in organophosphorus insecticides reflects the spread of soil insects resistant to chlorinated hydrocarbons. He points out further that as land values and operating farm costs increase, efficient insect control is becoming more and more essential as an insurance factor to farm profits.

Swimming Pool Ponds

Continued experimentation with the

Weighing in an experimental pheasant. Note the sock around the bird's body. This prevents leg and wing movements, can be slipped on and off readily, and permits easy handling of the birds without injuring them. (Photograph from Office of Agricultural Communications, University of Illinois.)

one-acre ponds at the Sam A. Parr Fisheries Research Center, Marion County, has demonstrated that, in bodies of water as large as these, naturally occurring variables produce a greater variation in fish production than has generally been recognized (*Reports,* No. 30). In an attempt to get some idea as to what variables in the environment might be affecting fish production, Dr. H. D. Buck and his colleagues C. F. Thoits and Russell Rose set up a series of experiments in plastic swimming pools 10 feet in diameter and 30 inches deep.

The bottom of each pool was covered with about an inch of soil, in six of them, a loam soil rich in organic matter, in the other six a sandy soil low in organic matter. The pools were stocked only with the tropical mouthbreeder, or tilapia, a vegetarian species that would feed on any plant growth that became established in the pool. Using this simple living system, two sets of experiments were run every day for 55 days and the increase in weight of tilapias measured for each pool.

Although analyses are incomplete, results from the three control pools are of great interest. In them, the tilapia increase was relatively uniform, differing by only 6 percent in the three pools. On this basis, these small pools with a simple living system may provide the experimental tool needed to understand the much greater fluctuations in fish growth found in larger bodies of water.

High-lysine Corn and Pheasants

One of the fascinating aspects of scientific investigation is the manner in which developments in quite different fields of endeavor dovetail to produce an exciting new horizon. This happened with high-lysine corn and pheasants.

Tabulating pheasant populations throughout the year, wildlife specialist R. F. Labisky and his colleagues discovered that young pheasant hens had a high mortality rate from October through December. Such mortality, reaching nearly 50 percent in some years, could not be attributed to the illegal kill of hens during the hunting season.

The investigators recognized also that in October, coincident with harvest time, large quantities of corn became available to the pheasants and in central Illinois this food formed nearly 90 percent of their diet for the remainder of the fall and winter. The young pheasants at the time of corn harvest would be from 14 to 18 weeks of age, or about two-thirds grown. During the spring and summer the birds feed on cereal grains, some plant foliage, earthworms, and a wide variety of insects. These varied foods decrease, and some almost disappear, as autumn progresses. The question arose: What effect would the switch from a varied diet to a straight corn diet have on the young birds produced during the preceding summer? A search of the biological literature indicated that practically no information was available on the nutritional requirements of pheasants. One publication did note that bobwhite quail live only about three weeks on a diet of corn alone. It was therefore decided to test the growth responses of young pheasants to a corn diet.

In the meantime, agronomists had developed a corn containing nearly double the amount of lysine (one of the amino acids necessary for growth) found in normal hybrid corn. Feeding experiments

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indicated that this high-lysine corn is of exceptional nutritional value for swine and laboratory rats. These findings suggested that high-lysine corn might also be a nutritional benefit to pheasants.

On October 20, wildlifers Labisky and W. L. Anderson set up a feeding experiment to test this possibility. Three groups of well-fed, 16-week-old birds were each placed on a different diet. One group was fed a balanced ration, another group only normal corn, and the third group only high-lysine corn. At the end of eight weeks, the hens fed on the balanced ration and high-lysine corn had average gains of 97 and 24 grams, respectively, but the group fed on normal corn had an average loss of nine grams.

Although these experiments are very preliminary, they indicate clearly that young pheasants thrive much better on high-lysine corn than on normal corn. Labisky and Anderson feel that the poor showing of these young pheasants on the normal corn diet may have an important bearing on the autumn die-off of young birds in the wild, and more intensive study of this problem is under way.

Should high-lysine corn become widely used on Illinois farms, the waste corn associated with the autumn harvest might make a tremendous difference in the survival of the previous summer's pheasant crop.

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JUNE 1967, NO. 56

Second Chance

Orchardists and gardeners alike have fought what seemed a losing battle with the common and destructive oystershell scale. It attacks many woody plants, especially lilac, dogwood, cotoneaster, apple, and willow, frequently killing young or susceptible plants. Oystershell scale overwinters in the egg stage, as minute white eggs protected under the dead female scale. In the latitude of Urbana, these eggs hatch into young nymphs called crawlers in early May. These crawlers wander about the tree and attach and feed on leaves, young twigs, or bark, become mature in a few weeks, and immediately lay their eggs, which are extremely difficult to kill.

It was previously thought that this scale had only one generation a year, and hence could be controlled only by sprays applied during early June when the scales had not yet laid their eggs. But because of sporadic weather hazards, this program was frequently ineffective.

Watching the scales closely throughout the year, Survey entomologist J. E. Appleby discovered that the eggs laid in June started hatching in July, and a second generation of insecticide-susceptible forms occurred from late July to mid-August, this generation being the one that overwintered. This second generation explains the rapid build-up of the scale and also provides a second period when the species is vulnerable to easy control applications. Dr. Appleby has found that standard sprays of malathion, diazinon, and several other insecticides provide an effective control if used on both the spring and summer generations.

Side Pocket Fishery

The value of floodplain pools to the fishery of a river has been graphically demonstrated by recent studies in the Kaskaskia River. In 1962 Survey aquatic biologist R. W. Larimore and his helpers, Michael Duever, D. L. Thomas, and P. A. Fishman, began an intensive study of fish production in a series of 25 oxbows in the Kaskaskia valley. A large number of these pools contain water throughout the year, even though they may be reduced in size during drier periods. Midsummer populations in these pools may amount to 1500 fish weighing over 1000 pounds per acre. In times of high water these pools are connected with the Kaskaskia River and large quantities of fish and fish food in the form of small aquatic animals

Oystershell scale on lilac twigs, enlarged at right. Each scale is about 1/8-inch long, brown or gray in color. (Photo by Survey photographer Wilmer Zehr.)

escape into the river proper where they contribute substantially to the river fish population. In the intensively studied oxbows near Sullivan, golden shiners, crappies, green sunfish, carp, and grass pickerel were the five most numerous sport species involved in these movements.

In these upstream oxbows the biologists discovered that bowfins and black bullheads occurred in the floodplain pools but very seldom in the upper river. Apparently these species prefer the pools. Presumably at high water a few individuals are washed into the river and find their way into other pools where they breed.

The floodplain pools proved to be especially important as a source of young for several species. Dr. Larimore and his crew found that crappies, golden shiners, largemouth bass, and buffaloes apparently did not spawn in the river but reproduced abundantly in the floodplain pools. Carp also reproduced in great numbers in the pools. At high water the young of these species moved or were flushed into the main stream of the river.

Not Catching

This spring, when sycamore anthracnose became extremely abundant on trees in many Illinois communities, the question arose: Does the disease spread between white oak and sycamore? White oak is attacked by anthracnose that produces a leaf blight very similar to that produced by sycamore anthracnose, and at the same time of year. Shade tree owners have been considerably worried that one tree might become infected from the other.

Because of a lack of precise information on this question in the scientific literature, Survey plant pathologists Dan Neely and E. B. Himelick made careful comparisons of the fungi on the two kinds of trees. Single spores from each were isolated and pure cultures of the two strains obtained. These were used in a series of cross-inoculation experiments using white oak and sycamore. In the case of each tree species, one set of trees was inoculated with the white oak strain, one set with the sycamore strain, and one, the check, with distilled water. The oak strain produced symptoms only on the white oaks, the sycamore strain produced symptoms only on sycamores.

Further laboratory studies indicated that the two strains differed also in the shape and size of their spores and in a variety of physiological reactions to various laboratory media. These studies indicate beyond any doubt that the two strains represent two entirely different species of fungi, each attacking only one host. If your sycamores get anthracnose, the disease will not spread to white oaks, and vice versa. If both your sycamores and white oaks get anthracnose, each species of tree is being attacked by a different kind of fungus.

Detection by Diet

Every day worried people write to the Survey wanting to know what to do about insects that are eating their corn, soybeans, phlox, lawns, shrubs, or trees. Sometimes the culprit is a well-known insect species and its identification is simple. Frequently it is either a poorly known species or is represented by larval stages that are extremely difficult to identify. Under these circumstances identification is hampered because of the large number of insects occurring in the state — 20,000 species at our latest estimate.

The brightest ray of sunshine through these difficulties is that most plant-feeding insects feed on only a few closely related kinds of plants. Certain insects feed on oats, wheat, and related members of the grass family; others on oaks, or sycamores, or elms; and so on. Intrigued by these insect-plant relationships, over the years a considerable number of entomologists have published lists of insect species feeding on particular kinds of plants.

Realizing the value of these insect-plant compilations as an aid in narrowing down the identification possibilities of suspected specimens, Survey entomologist M. W. Sanderson started bringing together these publications into an organized body of information. By 1962 Dr. Sanderson and his Survey colleague Dr. J. M. Kingsolver had located about 400 references and these were published as a preliminary progress report.

So useful was this experimental bibliography that our limited original edition was exhausted within a few weeks. Demands for a more extended bibliography poured in and Dr. Sanderson and Dr. Kingsolver — the latter in his new position with the USDA — solicited additions and suggestions from entomologists and botanists. The two authors have now completed a considerably augmented and more useful compilation, *A Selected Bibliography of Insect-Vascular Plant Associational Studies*, which is Publication ARS 33-115 of the Agricultural Research Service, USDA. Persons wishing copies of this publication should write directly to Dr. Sanderson at the Survey.

How Many Are There?

To evaluate different methods of wildlife management requires some means of estimating accurately the abundance of the populations under study before and after manipulation. If one could toot a whistle and have all the animals in the study area poke their heads up to be counted, the matter would be simple. The animals, however, simply do not cooperate. To find out their probable population numbers, some method of estimation must be substituted for the ideal of actually counting every individual.

Floodplain pool along Kaskaskia River near Sullivan. (Photo by Dr. Larimore.)

Methods of estimating small resident game animals such as rabbits and squirrels involve capturing and marking animals, releasing these into the same area from which they came, then recapturing additional samples. The total number of the population is estimated from either the proportion of marked to unmarked individuals in subsequent catches, or the number of times the same individuals were recaptured on subsequent days.

Population estimates based on the proportion of marked and unmarked individuals works well for situations in which the population densities are high and the probability of recapture is the same for all members of the population. For wildlife species such as rabbits and foxes, having relatively low population densities, the probability is low that any particular individual will be recaptured on any one day, and the probability is high that certain individuals will be recaptured more frequently than others because of proximity to the traps and for other reasons. Under these conditions the best population estimates seem to be those based on the number of times individuals are recaptured during a several day trapping period.

Several different mathematical equations have been proposed as a means of estimating the total population using these recapture methods. In order to find out which was the best, Survey wildlife specialist W. R. Edwards, in cooperation with Dr. Lee Eberhardt of Battelle Northwest, Richland, Washington, evaluated a series of capture-and-recapture tests run with cottontails in a 40-acre pen near Delaware, Ohio, and on a 100-acre study area at Allerton Park, Monticello, Illinois. In the 40-acre pen, 135 rabbits were released and estimates based on various methods of population estimation were checked against this known population.

In the Allerton area a different technique had to be employed to have a reliable estimate against which to check estimates based on trapping results. After wildlifer Edwards trapped and marked

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rabbits for a ten-day period, students of Dr. H. H. Shoemaker cooperated in a drive census in an effort to count the number of rabbits in the area. During trapping each rabbit captured was tagged with its own special number, and in addition its white tail was dyed bright yellow. At the end of the tests about 30 students beat across the 100-acre area, flushing out the rabbits and counting the number with white tails and the number with yellow tails. From this ratio the total rabbit population of the area was estimated.

When the capture-recapture data of the Delaware and Allerton tests were fitted to various mathematical models, it was found that the methods in general use grossly underestimated the field populations. With the help of Dr. Wayne Nelson, then of the University of Illinois Mathematics Department, a simplified equation was derived which gave a much more satisfactory estimation of abundance. Edwards and Eberhardt stress that in some instances this new equation, although giving results much closer to actuality than others so far devised, apparently tends to slightly overestimate the population. Although a long step forward as an aid in population estimation and one which appears to have application for estimating the abundance of a variety of species under certain conditions, this method is only one more tool in a bag which is yet far from full.

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JULY 1967, NO. 57

Tiny Trouble Maker

The old adage that small things are often the most destructive is certainly well borne out by Illinois' most recently discovered enemy of wheat, the wheat curl mite. Although it is less than 1/100 inch long when full grown, this tiny animal is capable of devastating wheat either by direct damage due to its feeding or transmitting the virus causing streak mosaic of wheat.

The wheat curl mite was first discovered infesting bulbs in California in 1938, and for 15 years was thought to live only on bulbs. In 1952 it was discovered on wheat in South Dakota, then more recently in Nebraska. It was first found in Illinois in 1966, at Brownsville. Since then Survey entomologist C. E. White has found the mite in almost every county in the state. He is working closely with University virus experts Henryk Jedlinski and H. H. Thornberry, who are studying the virus transmitted by these mites.

Survey mite specialist L. J. Stannard points out that this mite is easily disseminated by wind and apparently establishes new colonies readily. These tiny mites reproduce parthogenetically, each individual laying at least 12 eggs. During the warmer season they complete their life cycle from egg to egg in eight to ten days. Thus a small infestation can build up to tremendous proportions in a few months. The adults feed by scraping the leaves and imbibing the exuding plant juices. When numerous, the mites cause the wheat leaves to curl so that they resemble onion stems.

Although at the present time this mite is not a serious wheat pest in Illinois, it has tremendous potential for damage and is under constant surveillance.

Diseases by the Score

Green plants can truly be called the fountain of life. Unlike animals, the plants with their green pigments use the energy of sunshine to convert water and carbondioxide into sugars which in one way or another provide the energy that maintains

Mature specimen of the wheat curl mite, magnified 400 times. Actual length is about the diameter of the period at the end of this sentence, and only 25 times greater than a large bacterium. (Photo by Stannard and Zehr.)

all life on the earth. Thus the green plants are eaten by a tremendous variety of animals, and animals that do not eat plants are simply higher on a food chain in relation to animals that do.

But plants are eaten by more than animals. Certain plants have developed the ability to feed on other plants and foremost among these are the fungi. Fungi include mushrooms and toadstools that feed on dead plants that are still rich in nutrients and a wide variety of molds, mildews, and other less conspicuous types, many of which feed on living plants. It is this latter group that comprises the greatest variety of plant diseases, far outnumbering the bacteria and viruses that also parasitize plants.

The relation between the fungi and the green plants is highly complex. In some instances a fungus may have successive and quite dissimilar generations through a series of different host plants, alternating between one and the other. Pine blister rust, for example, alternates between white pine and gooseberry, producing entirely different shaped generations on each host. Sometimes the same fungus will attack a large number of different green plants, often producing different disease symptoms on each host. In other instances what appear to be similar symptoms on one host may be caused by a considerable variety of different fungus species. In total, a single plant host may be attacked by 20 or 30 quite different species of fungi.

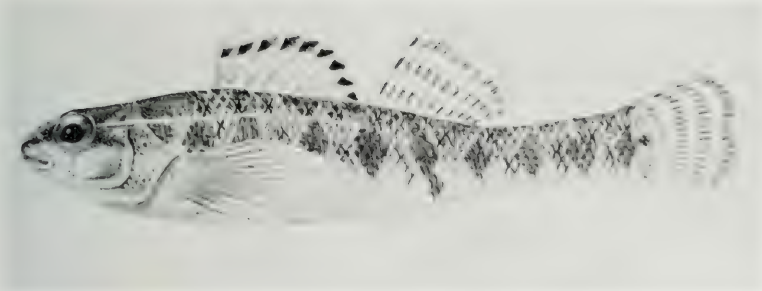
Because of this complex interrelationship between fungus and host, a thorough knowledge of the fungus flora is necessary in order to understand the plant disease problems of an area. Also, a reference collection of the known fungus flora is essential for the detection of new diseases. Realizing this, in 1921 the late Survey plant pathologist L. R. Tehon commenced a serious although poorly staffed attempt to collect and identify the fungi of Illinois. In 1930 Survey plant pathologist G. H. Boewe began a survey of the diseases of economic plants in Illinois, concentrating on fruits and grains, with some attention being given to forage and vegetable crops and the native flora. Thirty-seven years later he reports that he and his colleagues have accumulated over 34,400 study collections of Illinois fungi representing 1,500 species of fungi and bacteria attacking 1,200 host species in 428 genera of plants. Since 1921 a goodly number of previously undiscovered species have been unearthed and short reports made on the new discoveries of national scientific interest. It is now time to bring this tremendous mass of material together into a cohesive report that will undoubtedly serve as a milestone and reference point for the study of Midwestern fungi.

Parathion and Wildlife

The introduction of short-lived organo-phosphate insecticides as a partial substitute for the longer-lived chlorinated hydrocarbon insecticides raised a new question with regard to wildlife. The organo-phosphates do not persist long in the environment and hence do not present the hazard of accumulating undesirable residues. In general, however, the insecticidal organo-phosphates are faster acting than the chlorinated hydrocarbons. The question therefore arose: Was this faster action of the organo-phosphates introducing a new hazard for wildlife?

To obtain information concerning this question, in 1966 Survey wildlife specialists R. R. Graber and W. R. Edwards held pheasants, quail, rabbits, and white mice in open pens exposed to insecticide applications during normal field spraying of methyl parathion — a commonly used organo-phosphate insecticide — for control of the alfalfa weevil. Following these treatments the alfalfa weevils were controlled adequately, but there was no evidence of immediate mortality to any of the test mammals or birds.

During the 48 hours the pheasants and quail were held in the treated field following spraying, two of the four pairs of treated quail built typical, well-formed nests, one containing one and the other two eggs. This indicated a lack of interference with the normal behavior pattern during exposure to routine spraying. Some ill effects were noted. One quail and two pheasants died in the 18-day period follow-



The slough darter, its length seldom exceeding 1¾ inches. Dark markings of the front dorsal fin are red, those of the hind dorsal fin and tail are brown. (Photographs of a painting by Mrs. Alice Ann Prickett.)

ing the experiment. Some of the quail lost a little weight. And pheasant egg production was reduced for about a week. In these experiments, the sample sizes were small, hence the observed effects may have been due equally to either insecticidal exposure or to handling the birds during the experiments.

From the standpoint of lowered wildlife mortality, these preliminary tests indicate that parathion is a more desirable insecticide than the less toxic but persistent chlorinated hydrocarbons. More extensive experiments are needed with pheasants and quail to investigate possible long-range effects of parathion, and these tests are being conducted this season by wildlifer Edwards.

Slough Darter

Among the prettiest of Illinois fishes are some of the darters and minnows. In the fish world they compare with the warblers and kinglets of the bird world — they are small, brightly colored, the different species differ by many intricacies of color pattern, and the male has a brighter color pattern during the breeding season than at other times.

These tiny fish are part of the food chain leading from minute plant growth to minute aquatic animals to small fish to large fish. As such, the darters and minnows occupy an important place in the economy of fish production in Illinois streams.

They serve another important function that has to do with our evaluation of the quality of living conditions in different streams. Each species of darter or minnow reproduces successfully only in waters of certain types. Some live only in rapid clear riffles, others along the banks of large rivers, others in warm sluggish waters, and so on. After we discover the type of aquatic environment inhabited by each species, we can determine the kind of streams by sampling these fish and finding out which species are present in a given body of water.

These living indicators of stream conditions have a tremendous advantage over mechanical measurements of various stream characteristics such as temperature, current, turbidity, oxygen content, and so on. These physical factors vary from season to season, day to day, and hour to hour, and at present it is virtually impossible to accumulate the vast amount of recorded data needed to get an annual picture of stream conditions. These tiny fish, however, do give us just such a summation of the entire year's progression of change.

Comparing present-day collections with those taken 60 to 80 years ago, Survey ichthyologist P. W. Smith has found another use for these tiny fish. Changes in their distribution pattern in the state over this period of time is providing an accurate account of the changes that have occurred in Illinois streams during the state's metamorphosis from an area of primeval prairie and forest to a highly agricultural, industrial, and urban complex. But before these darters can be used as sources of this information, it is necessary to obtain accurate information concerning their environmental requirements and their life histories.

In conjunction with his assistant M. E. Braasch, Dr. Smith has just summarized information on the slough darter, known as *Etheostoma gracile,* a denizen of sloughs and sluggish creeks in the southern third of Illinois and southward and westward to

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the Gulf of Mexico. Intensive observations on the slough darter were made in Dismal Creek in Fayette County. These darters prefer quiet pools with clay, sand, or mud bottoms covered with fallen leaves, twigs, and other debris. Throughout the year the stream temperatures approximate closely those of the air.

These fish have fine reticulations of brown on the back and sides, overlaying a light yellow or tan, plus green blotches or bands on the sides. The back dorsal fin and tail are barred with brown and the front dorsal fin has a row of red dots. This front fin is usually clear, but the male's becomes blue black during the mating season.

The breeding season is in middle and late May. Each female apparently spawns over a period of only one or two days. She glues her eggs to twigs or leaf petioles anchored on the bottom, sometimes laying a row of 10 or 15 eggs along a single twig. The females apparently lay only about 50 eggs each and spawn only at the one time during the year. The males fertilize the eggs immediately after they are laid.

The eggs are round and gelatinous, about 1/64 inch in diameter. They hatch in less than a week into fry about ⅛ inch long. These grow extremely rapidly, attain a length of ⅝ inch in a week and an inch in six weeks. At this time they are colored like the adults. In five months they reach 1¼ inches, which is practically mature first-year size. After this the darters grow very slowly and in four years average only 1¾ inches long; the largest ever taken is about two inches long. Dr. Smith's statistics show that this species seldom lives more than four years.

These and other details of the life history of the slough darter are contained in the Survey's recently published *Biological Notes* No. 58, by Braasch and Smith. This publication is available on writing to the Survey.

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AUGUST 1967, NO. 58

Cereal Leaf Beetle Invasion

The cereal leaf beetle, a destructive pest of grain crops, was first discovered in the United States in Michigan in 1962. From there it spread rapidly into Indiana and Ohio and by 1967 it had reached Pennsylvania and Ontario. Since the first Illinois specimens of the beetle were discovered in 1965 on winter wheat in Will County, it has been found in nearly 40 localities, chiefly in the border counties adjacent to Indiana — Will, Kankakee, Iroquois, Vermilion, and Edgar — but also in Woodford County in the north central section of the state. Intensive surveys are being conducted in Illinois by the Plant Pest Control Division of the Federal Department of Agriculture and the Natural History Survey, but thus far the beetle has been found in small, non-destructive numbers. Survey beetle specialist M. W. Sanderson is working closely with federal pest control personnel in the identification of cereal leaf beetles and suspects.

Although the beetle's preference is for oats, it may damage winter wheat, seedling corn, and more mature corn following oats harvest. In Indiana, Ohio, and Michigan, badly damaged oats fields appear white as a result of inter-vein feeding by both adults and larvae. The beetle also feeds on a wide variety of wild grasses, which are native hosts in Central Europe where it may have originated.

The adult beetle is about one-quarter inch long and mostly blue in color with reddish legs. It flies readily. The fat larva appears black because of its slimy covering of excrement, possibly a mechanism of protection from the hot sun. The beetle passes the winter in the adult stage in stubble, husks, straw, under field trash, in wooded fence rows, and under any available cover. These adults may emerge from hibernation on a warm day as early as March. By late April and May they are present in large numbers and have commenced laying eggs singly on the under sides of leaves. Under favorable conditions the eggs hatch in one to two weeks. Larvae feed on the under surfaces of leaves and pass through four stages of instars within the next two to three weeks. Pupation occurs in the soil.

Most of the damage to cereals is done by

Cereal leaf beetle larva on oat blade, about ¼ inch in length. Note the black shiny excrement and the typical leaf damage. (Photo courtesy Plant Pest Control Division, USDA.)

adults emerging from hibernation, and by the summer generation of larvae, which feed until around July 1. Most beetles enter hibernation in August and September.

The rapid spread of the beetle after its discovery in Michigan is attributable to the absence of natural parasites in the developmental stages, coupled with available food in a latitude and under climatic conditions favorable for its development.

To combat the cereal leaf beetle, interstate shipments of baled hay and straw into Illinois are restricted by quarantines. In addition, parasite introductions and insecticide treatments are being employed to reduce the spread and destructiveness of this pest in the more heavily infested areas of Michigan, Indiana, and Ohio.

Prairie Chickens and Redtop Sod

Redtop grass has long been recognized as attractive nesting cover for prairie chickens in southern Illinois. However, it seems that the prairie chicken hens are particular about the age and condition of the redtop sod in which they place their nests. In order to keep the Illinois prairie chicken sanctuaries in attractive condition for nesting, it may be necessary to renew the sod periodically. This can be done by newly devised sod-seeding methods or by destroying patches of old sod and reseeding on a rotational basis within a sanctuary.

The need for this has come to light through studies of prairie chicken nests in predominantly redtop grassland by Survey wildlifer Ronald L. Westemeier. The sod in 517.6 arces of redtop grassland was grouped into five classes according to age ranging from one to four years of age and old sod (over four years of age). As expected, first-year sod was found to rank lowest in the preference of nesting hens. Second-year sod contained a nest density seven times greater than the old sod. Third-year sod ranked twice as high, and fourth-year sod ranked only slightly higher than the old sod. Although all classes of sod were used for nesting by the chickens, the younger, more economically productive stands of redtop, especially those with an admixture of red clover and with only a light layer of dead vegetation on the ground, seem to be the most attractive.

These studies have been conducted over a four-year period, 1963-66. Most of the data were collected from stands of redtop in close proximity to one another and to booming grounds of the prairie chickens. Therefore, the possibility of any bias due to selection by the chickens of one geographic location over another was minimized.

Who Needs It?

As if corn farmers do not have enough trouble controlling insects and diseases, a new pest has appeared recently in Illinois which could pose a further problem to corn growers in the state. Survey entomologist Ralph Sechriest describes the new pest as a white, insect-like arthropod known as the garden symphylid. Approximately one-quarter inch long, it has chewing mouthparts and feeds on the roots of corn plants. As many as 500 of these small animals have been found on the root system of a single corn plant. In such numbers the voracious symphilids can completely destroy the root system, leaving only a stalk which rapidly wilts and dies. When a root system has been consumed, the highly active animals move to adjacent plants in search of food, leaving rows of dead corn plants in their wake. According to Dr. Sechriest the garden symphylid is widely distributed in Illinois and surrounding states and has caused considerable damage to corn in Iowa, Indiana, and Ohio. It was not found on corn in Illinois, however, until 1965 when it appeared in a field in Woodford County. In June of this year high populations of the garden symphilid were discovered on the root systems of ten acres of severely damaged corn near Garden Plain, Illinois, in Whiteside County, 100 miles north of the original find.

Although garden symphilids can be found most everywhere in the state, they are not abundant and do not normally damage economic crops such as corn. They appear to be most destructive in soils high in organic matter. Very little is known of the biology and habits of symphilids but their appearance on corn, a major economic crop in Illinois, has caused growing

A. Smallmouth bass male x largemouth bass female F_1 hybrid. Age 56 days, total length 3.9 inches. B. Bluegill male x largemouth bass female F_1 hybrid. Age 56 days, total length 4.2 inches. C. Green sunfish male x largemouth bass female F_1 hybrid. Age 56 days, total length 2.9 inches. (Photos by Survey photographer Wilmer Zehr.)

concern among farmers and scientists working on crop research. Unfortunately, none of the insecticides presently recommended for control of corn insects are effective against the garden symphilid. Both Illinois fields in which symphilids were found on damaged corn had been treated with Aldrin, a widely used insecticide effective against many corn insects. The most likely hope for controlling this new pest according to Dr. Sechriest, lies with some of the new insecticide materials which are due to appear on the market in the near future.

Survey scientists are keeping a watchful eye on this potentially dangerous pest and are hoping to discover a weak link in its life history or biology which will lead to the development of economically profitable control measures.

Hybrid Bass

During the past ten years, Survey aquatic biologists William F. Childers and George W. Bennett have been studying hybrid sunfishes. They have found that a few kinds are quite abundant in many Illinois lakes and ponds. Most of these hybrids are the result of matings between closely related species such as bluegill, green, and red-ear sunfishes. All three of these species belong to the same genus, *Lepomis*. These three species have been hybridized in our laboratory by stripping eggs and sperm from ripe adults. All of the six possible cross matings between these three species have resulted in large numbers of first generation hybrids (F_1) which have been reared to maturity.

Hybrids between the warmouth (genus *Chaenobryttus*) and the three *Lepomis* species occasionally occur in nature. Stripping experiments in the laboratory revealed that hybrids from two crosses, warmouth male x red-ear female and warmouth male x bluegill female, all died before they became free-swimming; however, the other four kinds of hybrids were highly viable and have been reared to maturity.

Hybrids between more distantly related sunfish such as largemouth bass and the three *Lepomis* species are exceedingly rare in nature. A few largemouth x bluegill hybrids were found in one reservoir in the Hawaiian Islands and natural hybrids from largemouth bass x green sunfish crosses are not known to occur.

During May, 1967, Dr. Childers and Dr. Bennett, by stripping eggs and sperm from ripe adults, hybridized a female largemouth bass with smallmouth bass, rock bass, bluegill, green, and red-ear sunfish males. Hatching occurred in all crosses; however, the rock bass x largemouth and red-ear x largemouth hybrids died before becoming free-swimming. Several thousand individuals from each of the other three crosses did develop into free-swimming fry and were isolated in ponds

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containing no other fishes. The sex ratios, rates of growth, and reproductive success of each of these populations will be studied during the next several years.

The bluegill x largemouth bass cross has been attempted in the laboratory by Mr. West and Dr. Hester of North Carolina State University. These investigators reported two viable hybrids from approximately 1,000 eggs. The green sunfish x largemouth bass and the smallmouth bass x largemouth bass hybrids are believed by Childers and Bennett to be the first ever produced.

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Kissing Bugs?

The kissing bug, also called bloodsucking conenose, blood sucker, and big bedbug, has been known in Illinois for 100 years. About seven-eighths of an inch long, flattened, black or dark brown with orange patches on the sides, it got its name "kissing bug" because of its habit of biting humans principally on the lips and about the face as they sleep at night. Its bite is painless, but some individuals are hypersensitive and may experience swelling, a burning sensation, itching, and general discomfort. The kissing bug is known to be a vector of Chagas' disease in parts of Texas and Mexico — a disease which particularly affects heart cells. An extensive survey for the disease organism in Illinois has failed to show its occurrence in the state.

The bug, known by its scientific name *Triatoma sanguisuga,* occurs throughout eastern United States from Texas to Kansas and east to Pennsylvania and Florida. In Illinois it has been found in 15 counties, principally in the southern and western parts of the state below Quincy, but it is known to occur as far north as Lacon in Marshall County.

Since the original discovery of the kissing bug in Georgia over a century ago, it has been known to be closely associated with the dwellings of man. Under natural conditions it occurs under bark of trees, and in nests of various kinds of mammals, especially woodrats. It is occasionally found in chicken houses. Because of its long association with man, it has become partially domesticated. Man is a more available, if not willing, source of food than its wild mammal hosts.

During the day the kissing bug normally hides in dark cracks and crevices in walls, even in old mattresses. But in the dark of the night the winged adult moves out of hiding in search of a meal of blood. Young kissing bugs may continue to hide, not often coming out to feed on man. To obtain food, the young bug with its beak punctures the skin of an older brother or sister, and sucks its blood or hemolymph until satisfied. He may thus be fed upon (parasitized) by a younger brother or sister, and the older, but not yet adult, bugs will feed through the blood distended skin of adult bugs. They may even feed on the blood of engorged bedbugs.

The kissing bug, adult female. (Photo by Survey photographer Wilmer Zehr.)

With the approach of cold weather, the kissing bug goes into hiding for the winter, usually as an adult. It may retreat deeper into the walls of buildings, and into the nests of small mammals. In southern Illinois it emerges from winter quarters as early as March or April. There are five nymphal stages, but the duration of the stages will depend on how frequently the bug has fed.

While the kissing bug is not known to be a carrier of Chagas' disease organism in Illinois, it is considered as a health hazard because an occasional person may become hypersensitized and ill following the bite. Otherwise some people may never know that kissing bugs are in their house.

Which Wilt Is Which?

Russian olive, a tree species noted for its light grey, willow-shaped leaves and low, spreading branches, has long been favored as a landscape plant for highway and ornamental plantings. Unfortunately, the desirability of this species has been lowered by its high susceptibility to Verticillium wilt, a vascular fungus disease which causes wilting and dieback of branches. Now another disease has appeared which may reduce the value of Russian olive even further.

In 1962, in the St. Louis area several specimens of Russian olive, which had wilting and dying branches, were brought to the attention of Survey Plant Pathologist J. C. Carter. An examination of the affected trees revealed the presence of large, sunken cankers on the trunks and main scaffold branches and numerous smooth, reddish-brown cankers with dark brown margins on smaller branches. When these cankers were observed under the microscope, black fruiting bodies of the fungus *Fusicoccum* were found, indicating that this fungus may be the cause of the disease. When healthy Russian olive branches were inoculated with the isolate, typical cankers were produced and fruiting bodies of the fungus appeared in the cankers, proving that the fungus was in fact the cause of the disease. Dr. Carter and a scientist from the University of Missouri named the new species *Fusicoccum eleagni* after the host *Eleagnus* (Russian olive). The identification and description of this new species, published in the scientific journal *Mycologia,* will aid Plant Pathologists in identification of the disease and will form a basis for determining its distribution and economic importance.

Since cankers were produced readily when healthy branches were inoculated, regardless of the time of year inoculations were made, the disease may be potentially quite destructive if the fungus becomes widely distributed on Russian olive. Survey Pathologists are now alerted to the presence of *Fusicoccum* canker on Russian olive and will be examining diseased trees closely to see if this disease is on the increase.

Redressing the Balance

In nature an insect pest is often kept under control by natural enemies. An insect pest, when it is first introduced into a new region, usually finds few natural enemies awaiting it. This lack of parasites and predators allows the insect to multiply and spread rapidly.

When the alfalfa weevil arrived in the United States from Europe, it found few natural enemies and multiplied and spread rapidly to the point that it has been termed our most destructive pest of alfalfa. It was first recorded damaging alfalfa in the area of Salt Lake City, Utah, in 1904. It was discovered in Illinois in 1964. Entomologists of the USDA have introduced parasitic wasps from Europe into this country to help control the weevil. These parasites are reared and distributed to the various states by the USDA Parasite Forwarding Station at Moorestown, New Jersey.

Natural History Survey entomologists have been active in disseminating enemies of the alfalfa weevil in Illinois since 1964. Dr. Dysart, now a member of the USDA staff searching for parasites of the weevil and other insects in Europe, released three parasitic wasps in 1964. A larval parasite, *Tetrastichus incertus,* a parasite of the pupal stage, *Dibrachoides druso,* and a parasite of the adult weevils, *Microctonus aethiops,* were released in southern Illinois. In 1966 entomologist Edward Armbrust

 

On the left is the improved nesting house with a duck flying from the entrance. On the right is a hen in a nesting house on eggs and ducklings. (Photos by Survey photographer Wilmer Zehr.)

joined the Survey staff to continue alfalfa weevil research and, more recently, entomologist Clarence White has devoted much time in releasing and recovering parasites of the weevil.

A fourth wasp, *Bathyplectes anurus*, which parasitizes the adult weevil, was released in Illinois in 1967 along with additional colonies of those parasites released earlier. During the past four years a total of 47 colonies of all parasites have been released in 38 counties in the southern half to the southern third of the state. An unsuccessful attempt was made in 1967 to recover parasites from earlier release sites. This may mean that the parasites introduced did not become established or that the populations of the parasites are as yet so low that they cannot be detected by our small sample techniques.

Another parasitic wasp, *Bathyplectes curculionis*, which attacks the alfalfa weevil larva, has been found in 22 counties in Illinois, although this wasp has never been released in this state. In some fields in Illinois as many as 50 per cent of the larvae of the weevil were found to be parasitized by this wasp. This parasite was released in Kentucky prior to the time that the alfalfa weevil had been found in Illinois and has no doubt moved north along with the weevil. It is not a satisfactory ally in our battle against the weevil, as it appears too late in the season to reduce the weevil populations to levels which do not cause economic loss.

Burglar-proof Wood Duck House

The wood duck is among the most important ducks in Illinois. The sportsman finds the wood duck to be second or third in abundance in his bag. The bird watcher finds the wood duck to be our most colorful duck and with especially interesting nesting habits.

Wood ducks normally nest in cavities in hollow trees 20 or 30 feet from the ground. After the eggs hatch, the ducklings drop to the ground usually without injury as their bones are still very pliable and not easily broken, then waddle off with their mother to the nearest body of water. Prime nesting sites along the Mississippi, Illinois, Wabash, and Ohio rivers are disappearing as bottom lands are cleared for corn or other crops. However, this duck takes readily to man-made nesting boxes on fence posts or hung in trees.

Survey staff wildlifers Frank Bellrose and Robert Crompton are currently continuing a long-term study of wood ducks in Illinois with the objectives of, first, developing a successful nest box in order to increase populations of the ducks and,

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second, studying the homing of adults and yearlings, mortality, success of nesting and of the young.

The nest house design has had several objectives over the years. Predators of the eggs and young had to be excluded. Squirrels, bull snakes, and raccoons have been among the most important predators. The worst predator was the coon which not only destroyed eggs and young but would also take an occasional brooding hen. In recent years starlings have taken over artificial nest boxes, destroying eggs so that the box is abandoned by the ducks.

Nest houses were constructed first of wood. The entrance was a flattened ellipse about 3 inches tall by 4 inches across. This excluded most coons but squirrels and bull snakes still took their toll of eggs. An improved house was next made of sheet metal with sawdust inside. This design excluded the squirrels and snakes and was acceptable to the ducks, but coons still could enter by reaching down from the top or around the box. A smaller entrance could restrict the admission of most coons, but starlings then usurp the box.

Starlings, in recent years, have become very abundant in Illinois. In nature a starling will not usually nest in a cavity with an entrance of five inches or more in diameter. In 1967 nest houses were tried which were large enough and the entrance so placed that even the larger coons could not reach it from the top or sides and with the entrance five inches in diameter so as to deter starlings.

Many birds are known to avoid red colors and it seems that the starling is one of these. Therefore, wildlifers Crompton and Bellrose decided to try using sawdust dyed red as nesting material. In 40 boxes, 20 with red and 20 with natural sawdust placed alternately in the trees near the Survey's Havana lab, only one box with red sawdust was usurped by starlings, whereas 12 with natural sawdust were usurped. The red sawdust does not seem to deter the wood ducks from nesting.

The wildlifers can now recommend a metal cylindrical house, 14 inches in diameter, with a five-inch circular entrance placed 31 inches from the tip of the conical top and 16 inches from the bottom, the entire box being 52 inches top to bottom and with red sawdust inside as the best artificial nest house in Illinois. A Natural History Survey circular is being prepared which will embody these recommendations in more detail.

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Frog Legs on the Hoof

Illinois bullfrogs grace more tables in the the state than most people realize. To many, bullfrog hunting is a marvelous sport. Most frogs are captured by hand while they are blinded by a flashlight beam or are "gigged" with a barbed spear. In Illinois it is illegal to hunt them with fire arms, air guns, or gas guns. The daily limit is eight, and one person may have only eight in his possession at one time.

The larger bullfrogs range in size from three-fourths to one pound but half-pound frogs are considered a good size for eating. When its hind legs are stretched out, a half-pound frog will measure about a foot from its nose to the tip of its hind feet. The legs and backs of three moderate-size frogs make a good meal for one person.

Frog farming is usually not successful because bullfrogs are cannibalistic and subject to a disease called "red leg." As a result, almost all Illinois table frogs are caught in the wild, either locally or shipped in from southern states. Remarkably little is known about the habits of these frogs in Illinois, especially the potential crop in a given area. To get some idea of these potentialities, this summer Survey aquatic biologists G. W. Bennett and H. W. Adkins began gathering data concerning home territories of bullfrogs, their abilities to return to home territories when transplanted to other areas, and the extent of natural frog migrations. These studies were based on capturing, marking, and recapturing frogs at Ridge Lake in Coles County. The simplest marking method was removal of the tips of various toes. A frog has four toes on each front foot and five on each hind foot, so that a very large number of combinations are possible. Some frogs were marked by impregnating the skin with fluorescent pigments that glowed in ultraviolet light. In this study a total of 90 bullfrogs were marked and released after being weighed and measured.

Of the displaced frogs, many of the larger ones moved back to their home territories. One collection of 24 frogs was moved 50 yards up the dry stream channel above the lake. When released they moved off in all directions, but two weeks later five of them were back in their home territories in the lake. Frogs were collected and released at weekly intervals through the summer. If the frog population had been stable, the proportion of marked to unmarked frogs should have risen steadily

The bullfrog, Illinois' largest frog. Large ones reach a pound and may be near a foot and a half long from nose to toes when the hind legs are stretched out. (Photo by former Survey photographer Wm. E. Clark.)

week after week. This, however, did not occur. Regardless of how many frogs had been marked previously, half of the frogs captured on any one night were unmarked new frogs. This indicates that there was a constant movement of frogs in and out of the lake.

The fact that some members of the bullfrog population have these migrating tendencies apparently makes it possible to remove large numbers of bullfrogs from relatively small areas. When resident frogs are removed, others will move in to replace them.

Juniper Blight

In most years juniper blight is widespread throughout Illinois, but it causes little damage, except perhaps locally. But in 1966 and 1967 it became epidemic over most of the state. Damage to many plantings was severe and some plantings sustained so much injury that they had to be removed.

Juniper blight is caused by a fungus called *Phomopsis juniperovera* which kills the end twigs usually for a distance of 2 to 6 inches back from the tip. In highly susceptible varieties this damage may extend to some of the main branches, causing large portions of the juniper to appear blighted.

Survey plant pathologist D. F. Schoeneweiss believes that the unusual epidemic of the last two years has been due primarily to unusually favorable conditions for the fungus, which thrives best during cool, wet weather in the spring. Dr. Schoeneweiss also points out that the fungus is very easily spread on pruning and shearing equipment and farm tools, so that if the disease gets a good start during the early-summer shearing season, it can spread rapidly throughout an entire plantation.

It is well known that different varieties and cultivars or selections of its hosts exhibit different degrees of susceptibility to the disease. Because information on these variations in susceptibility to juniper blight was sparse, in June and July of last summer Dr. Schoeneweiss surveyed the relative amount of damage on 156 species, varieties, and cultivars of juniper, arbovitae, and false-cypress. Data were collected from specimen plantings at the Morton Arboretum and from stock plantings at the D. Hill Nursery Co. and the Egyptian Nursery & Landscape Co. Only plants which had fruiting bodies of *P. juniperovora* present on damaged tissues were considered diseased.

A tabulation of the results indicate that most arbovitae and false-cypress are relatively resistant to juniper blight, but that the various cultivars of juniper species range from highly resistant to highly susceptible. Dr. Schoeneweiss is now preparing a tabulation of this information for publication so that information concerning the relative susceptibility of junipers and other hosts will be available to nurserymen and landscapers.

A Rare Jewel

We tend to think of the different kinds of insects as being either destructive, such as grasshoppers, or common and widespread, such as the butterflies and hover flies that we see frequently in travels over the countryside. It is not too well appreciated that many of our insect species are either highly local in distribution, as for example the tiny thrips that live only in the flowers of the Indian pipe or rare creatures seldom seen except by the assiduous collector.

The list of these rare Illinois species includes a sizeable number of beetles, butterflies, moths, crickets, and grasshoppers, in fact, practically every group of insects. Many species rare in Illinois, however, are more common, if not abundant, in other parts of North America. Interesting examples are bog and marsh species known in Illinois only from the extreme northeastern corner of the state, but widespread in the north-woods country of eastern United States and southern Canada. A few insect species appear to be exceedingly rare wherever they are known. The discovery of such an insect is a matter of special interest.

It was a real thrill when Murray O. Glenn, long-time collector and expert on the moths of Henry, Illinois, recently brought one of these treasured findings to

The lacewing *Nallachius americanus.* This fragile insect has a wing spread of ⅝ inch. Note the slender ovipositor extending from the end of the abdomen. The "spike" is the insect pin on which the lacewing is mounted. (Photo by Dr. W. E. LaBerge.)

the Survey. It proved to be an Illinois "first," one of the most rarely captured North American insects, a fragile, mottled lacewing called *Nallachius americanus,* belonging to the insect family Dilaridae. A second North American species of *Nallachius* is known to exist only in Cuba and Arizona. A number of other genera and species of Dilaridae occur only in the Old World.

Survey entomologist H. H. Ross notes that *Nallachius americanus* was first described from a single female taken at Bee Spring, Kentucky, in June, 1874. Since then individual specimens have been taken at long intervals from scattered localities from Georgia to Michigan. Mr. Glenn's specimen was taken at Putnam, Illinois, August 16, 1966.

The larvae of *Nallachius* are slender, pale, and almost wormlike and live under the bark of freshly dead trees. They apparently are predacious on soft bodied larvae and eggs of other insects that live in this same microhabitat. Entomologists who have studied this insect in Maryland report that the larvae show a strong preference for tulip poplar and several species of oaks. The adult female apparently uses her long slender ovipositor to develop eggs at the bottom of bark crevices.

Bedtime Story

The mourning dove is usually considered as a bird that spends the night roosting in trees, but in recent years wildlife investigators have reported that in winter the birds roost on the ground. Nightlighting studies of pheasant roosting provided an opportunity to discover the details of this changing pattern of night roosting. The studies were conducted by Survey wildlife researchers J. A. Ellis and W. L. Anderson near Neoga in Cumberland County, Illinois. During the nightly cruising for pheasants Ellis and Anderson also recorded the numbers of ground-roosting doves and the particular kind of habitat in which they were found. This information has recently been summarized by former Survey wildlifer S. L. Wunderle.

From July 23 through September 16, no ground-nesting doves were observed on 789 acres having vegetation ranging from 1 inch to 4 feet high. From September 23 through November 13, a total of 254 doves were flushed by cruising 661 acres having the same vegetation range. The doves were highly selective in their choice of the kind of vegetative cover for roosting. Ninety percent of them roosted in vegetation containing clover as the predominant plant.

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In 290 acres of wheat and oat stubble regrown with weeds and grass only nine doves were found, indicating a remarkable preference for the more solid clover vegetation.

The doves were also highly selective concerning the height of vegetation in which they roosted. Ninety percent of them chose vegetation under six inches high. Doves found in vegetation over six inches high were in open areas within the vegetation or on piles of dead vegetation.

At least two factors may be involved in this initiation of night ground-roosting by doves after September 23. This date coincides with the time that leaves were falling from the trees, in particular from the osage orange hedges where the birds had been observed roosting during July, August, and early September. One factor may be that leaf fall made tree roosting more hazardous from the standpoint of decreased protection from enemies. A more probable possibility is that the doves roost on the ground at this time to conserve body heat. Several physiological investigations of doves have shown that on clear cold nights it is necessary for the birds to roost in a place relatively free of air movement to cut down radiation of heat from their bodies. It has also been discovered that doves attain their highest metabolic rates in September and that in the mourning dove metabolism is more affected by slight changes in air temperature than is the metabolism of non-migrant ring doves and pigeons.

This need for protection from air movements explains choice of the denser clover cover for ground roosting. It is possible that the lower vegetation aids in a more rapid take-off at the approach of danger.

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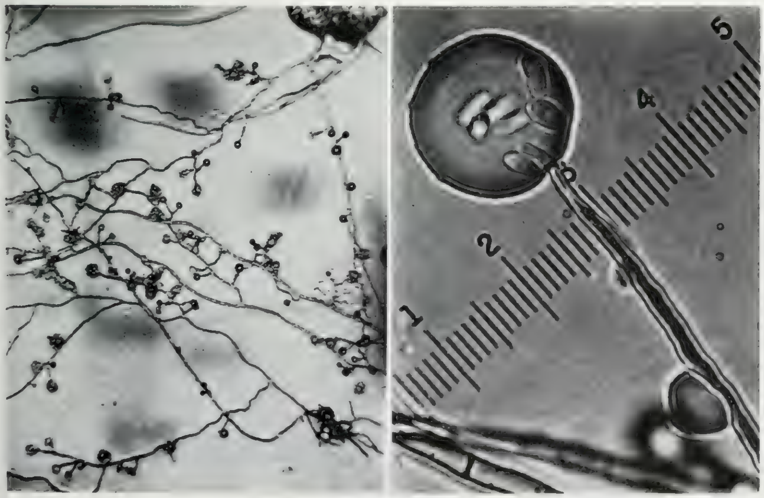
Puzzling Killer

Fungus species that attack plants differ greatly in their results. A large number of them, including oak wilt and Dutch elm disease, each attack only a few closely related species of trees and are always fatal to their hosts. Other fungus species, like the mildews, may infect their hosts in great profusion and seldom do more than retard the growth of the host plant. In most instances we know how these diseases are transmitted from plant to plant. Sometimes their light spores float on the air currents from host to host: sometimes the spores are carried by insects, birds, or other animals from one host to another.

One of the common sources of concern to home owners and arborists is the Verticillium wilt fungus, a species that fits none of the tidy categories just outlined. Typically, when a tree becomes infected, its leaves first discolor, then look scorched, and may fall off. The wood becomes discolored, and the tree may die. Sometimes the fungus kills only an individual large branch, producing a dieback condition. In other instances many branches may die, producing a staghead condition in which the dead branches protrude out of an otherwise healthy tree; often if the dead branches are removed, the rest of the tree may live and appear to be unaffected by the fungus. The rapidity of action varies greatly. In the same test plot and using the same species of test tree, some trees die in a few months, others only at the end of several years.

Verticillium wilt has a wide range of victims. Common hosts include sugar and Norway maples, Russian olive, ash, tulip tree, linden, redbud, and magnolia. Another 80 or more kinds of shade trees and shrubs may be affected. So also may be peppermint, tomato, and eggplant. This



Verticillium wilt fungus from artificial culture. *Left,* strands of fungus mycelium with round fruiting bodies arising from it. *Right,* a single fruiting body showing its terminal gelatinous ball in which the minute spores are formed. The diameter of each ball is about 16 microns, less than 1/1000 of an inch. (Photos by Dr. Himelick.)

list is a remarkable spectrum of different species ranging throughout the whole family tree of the higher plants.

In getting a better understanding of this fungus disease, Survey plant pathologist E. B. Himelick points out that there are two important blanks in our knowledge of it. First of all, no one yet knows how the disease is transmitted in trees. No fruiting bodies have yet been discovered on the outside of the tree, although it produces spores profusely internally. When affected plants die and their roots rot, however, they may leave masses of infective fungus in the soil and it may be that some transmission occurs when new plants are set out in a spot where previous plants had died of the fungus.

The second important gap in our knowledge concerns how the fungus gets from one part of the tree to another. To try to get some information on this score Dr. Himelick and his assistant G. L. Born are following two lines of experimentation. It seems certain that the fungus spores travel through the vascular systems of the plant. In different species of plants the size and length of the vessels in this system may be quite different and experiments are under way to determine what effect especially the width of these vessels has on the ability of spores to move through them. Another factor that might influence spread of the fungus within the tree concerns the rapidity with which spores are formed in the tissues. To test this, plant pathologist Born is studying the effect of sap extracts from different hosts on the germination of fungus spores. It is hoped that these and subsequent studies will ultimately give some clues which will lead to better control of Verticillium wilt.

Welcome Holdout

As the pollution load in the Illinois River continues over the years, many species of fish that once lived in the river are apparently being eliminated from it. One of these species seemed to be the blue sucker. This bizzare large-river fish requires good current and gravelly riffles. At the turn of the century blue suckers were caught in considerable numbers in the Illinois at least as far upstream as Havana, where it was considered of some commercial importance. Since then its numbers had declined steadily, and it had been so long since a specimen had been caught in the Illinois that the blue sucker was thought to be completely eliminated from the river.

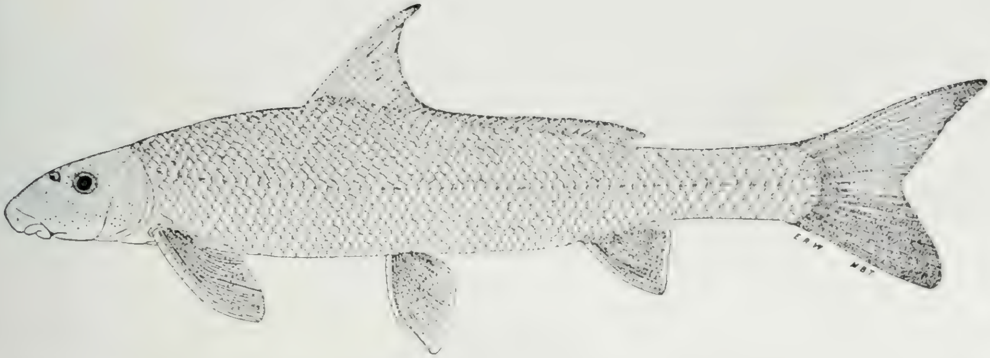
In recent state-wide surveys conducted cooperatively by Survey fish specialist P. W. Smith and the State Department of Conservation, the blue sucker has been located very sparingly at a few points along the Wabash, lower Kaskaskia, and Mississippi rivers. A fish of the Midwest, its numbers have apparently been reduced throughout its entire range.

Many of the commercial fishermen along the Illinois cooperate with Survey aquatic biologist W. C. Starrett in reporting unusual fish catches. One morning this summer Mr. Sam Kelly, one of the cooperating fishermen, called Dr. Starrett and said that, in his nets set in the river above Havana, he had caught a fish that might be a blue sucker. Mr. Kelly's opinion was correct; he had a blue sucker 23 inches long, weighing 4½ pounds.

Where the fish came from is a matter of conjecture. Small numbers of blue suckers may have maintained a local population in some little-collected part of the river. Perhaps the fish came up the Illinois River from the Mississippi during the spring rise in water level, when the pollution is most diluted. The presence of the blue sucker does indicate that if pollution conditions in the Illinois were to improve, many of its former fish denizens would again become established in its waters.

Soybeans and Insecticides

One of the problems connected with the long-lived chlorinated hydrocarbon insecticides such as DDT and aldrin has been that these chemicals are absorbed by certain plants and deposited in edible structures such as leaves and seeds. With corn and the grain crops such deposits are not a problem because if any of the insecticides are stored in the harvested seed it is



The blue sucker, one of Illinois' rare fishes. Note the unusual shape of the top fin. (Illustration from *The Fishes of Ohio.*)

in ultra-minute quantities that frequently are so low as to be undetectable by the most sophisticated chemical analysis. Alfalfa stores some of these insecticides in its foliage, and for this reason Survey entomologists have warned farmers for many years not to use chlorinated hydrocarbons on alfalfa used as feed for milk cows.

The ability of soybeans to absorb these insecticides and store them in the seeds has been of continuing concern. It is not a problem in domestic use because the high-temperature steam hydrolysis used in the preparation of foods from soybeans disintegrates the insecticides and thus eliminates them. In the case of soybeans sold as raw beans for export, however, the problem still exists because many countries will not allow the importation of soybeans containing these insecticide residues. When soybeans leave the farm there is no certainty as to whether they will go into a local food processing plant or be exported as beans, hence it is important to take all precautions to keep their insecticidal residues low. For this reason the organophosphorus and carbamate insecticides are replacing the chlorinated hydrocarbon insecticides for controlling soybean insects.

In order to find out if the soybean plants absorbed the organophosphorus insecticides and deposited them or their undesirable by-products in the seeds, Survey entomologist W. N. Bruce tested the two common ones in general use, diazinon and parathion, in a series of field experiments. Plots of soybeans were treated with dosages of these two compounds at rates from 2 to 10 times the normal dosage and at more frequent intervals than usual. Although these compounds have a relatively short life, under these conditions of heavy application by August the soils still contained appreciable amounts of the insecticides. At harvest time, however, neither parathion nor diazinon was found in the soybean seeds.

Who Gets the Crop?

By each new breeding season, the Eastern Illinois pheasant population has been reduced by mortality over the fall and winter to the point where it started the year before. In a sense, this fall and winter mortality represents a cropping of pheasants that is necessary for their population to remain stable.

Since 1962, Survey wildlife ecologists Stan Etter, John Warnock, and Blair Joselyn have studied these ups and downs of pheasant populations on the 36-square-mile Sibley study area in Ford County. Each year substantial numbers of pheasants were captured during October and early November and again during January and February. Changes in the sex and age ratios between the two trapping periods indicate that juvenile pheasants survive only half as well as adults from October to February. By comparing the age ratios of cock pheasants killed during the hunting season with those captured during the fall trapping periods it was

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found that even among the cock pheasants there was a high mortality of juveniles in early winter as a result of factors other than hunting. It appears that the higher survival of adult pheasants is due to a greater ability to adapt to the drastic changes in environment brought about by crop harvest, fall plowing, and the onset of winter weather conditions.

Differences between fall and winter populations indicated that about half of the hen pheasants and only about 10-15 percent of the cock pheasants alive in October survived until the following March. Applying the sex and age ratios from the trapped samples to these changes indicates a survival rate of 75 percent for adult hens, 38 percent for juvenile hens, 20 percent for adult cocks, and 11 percent for juvenile cocks. Thus it appears that a high mortality occurs during the late fall and early winter period.

While hunting is the most conspicuous cause of mortality of cock pheasants, only about 65 percent of their mortality, including crippling losses, could be attributed to hunting. This fact was true even in 1962 when the harvest of cock pheasants was higher than in any following year. Estimates of illegal kills of hen pheasants indicate that only about 10-15 percent of the hen losses could be attributed to hunting. It is thus apparent that both non-hunting and hunting mortality together exert a controlling effect on the size of pheasant populations.

This situation raises the possibility that if hunting were increased, it would not jeopardize the pheasant population, but would simply decrease mortality from non-hunting causes. Although our knowledge of these non-hunting causes is far from complete, it is sufficient to indicate clearly that the mortality rate of cock pheasants due to hunting could be increased without endangering the pheasant population as a whole.

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Fish and Crayfish

It has been assumed that anything as slow as a crayfish would have little chance of catching something as fast as a fish. For this reason the predation of crayfish has not been considered important in affecting fish production in various bodies of water.

When studying carp production in one-acre ponds at Forbes State Park in 1966, Survey aquatic biologists H. D. Buck and C. F. Thoits noticed that ponds producing the largest crop of carp seemed to have the least number of crayfish, whereas ponds producing the smallest crop of carp appeared to have much greater crayfish populations. To test a possible correlation between crayfish and fish production, in early summer of 1967 a series of wading pools were each stocked with the same initial number of carp and different numbers of crayfish. At the end of the summer the survival of carp and their gain in pounds per acre was measured.

The analysis of these figures is extremely interesting. Up to 25 crayfish per pool had no effect on survival and apparently only slight effect on the poundage gain by the carp. Fifty crayfish per pool also had no effect on carp survival but produced a one-third decrease in the poundage gain by the carp. Seventy-five crayfish per pool eliminated 70 percent of the individual carp and reduced the poundage gain to only one-sixth of that in the check pools that had no crayfish.

Although no studies were made on the actual behavior of the animals, Dr. Buck

These crayfish (also known as crawfish or or crawdads), which commonly attain a length of 4 inches, are common inhabitants of Illinois ponds and streams. They move forward slowly but can scuttle backwards rapidly. (Photo by Dr. G. W. Bennett.)

points out that these figures show a fish-crayfish relationship that becomes critical at high concentrations of crayfish. In lower concentrations, the nuisance factor of crayfish activity results in little mortality but keeps the carp on the go so much that they gain less than when undisturbed. When present in unusually large numbers, the crayfish probably tire out the carp enough that they are vulnerable to direct crayfish predation.

Apple Serendipity

Serendipity may be described as "two for the price of one" and this may be exactly what will come from some current investigations with apples. In most years fungicidal control for apple scab works wonders, but in seasons with weeks of wet weather when sprays can not be applied successfully, scab will sporadically get out of hand and cause heavy commercial losses. In an effort to tackle this in another way, horticulturists from the University of Illinois, Southern Illinois University, Purdue University, and Rutgers University are co-operating in breeding experiments designed to produce a scab-resistant apple variety that will also produce high grade fruit.

The Japanese crab apple, highly resistant to scab, is being used as one parent, various commercial apple varieties as the other, and hybrids of various combinations are being tested.

In checking insect damage on some of these scab-resistance plots, Survey entomologist R. H. Meyer noticed that some seedlings were heavily infested with mites whereas adjacent seedlings appeared to be mite-free and healthy. This finding suggested that some sort of mite resistance might also be involved in these various genetic combinations. This idea was intriguing because mites, like scab, are always potential threats that can develop explosively and without warning in apple orchards.

Following these initial observations, last summer Dr. Meyer artificially infested a number of parents and hybrids with mites. He found that the Japanese crab apple appeared to be highly resistant to mites, most of the commercial varieties were highly susceptible, and at least some hybrids gave evidence of mite resistance. These preliminary experiments also indicated that the genetic basis of mite resistance was not simple, hence it would take more sophisticated tests to find out if mite resistance could be coupled with scab resistance in a new commercial variety. This avenue of investigation will be followed during the coming year.

Tiny Pushups

Almost universally throughout the fungi there are no special structures that function only for the purpose of breaking host plant tissue and thus making a release opening for the escape of fungus spores. Until recently the only fungus for which this phenomenon was known was the oak wilt fungus. In this species a cushion of fungus mycelium is produced between the bark and the wood, then the cells of the cushion swell and make a break in the bark. The fungus spores then form in this area and escape through the break.

In his studies of sycamore anthracnose, Survey plant pathologist Dan Neely was convinced that spores produced on the twigs were the most effective source of spring re-infestation of sycamore trees with the anthracnose fungus, and he set out to find the mechanics of this spore formation. Very thin microscopic sections of diseased twigs were made at intervals of 12 microns (1,000 microns equal about 1/32 of an inch), and the tissues were treated with special stains permitting the identification of various tissues of the host twig and of the types of mycelium and spores of the fungus. By examining hundreds of these sections it was possible to reconstruct the development of the fungus in the sycamore bark. When this was done, Dr. Neely discovered that the fungus causing sycamore anthracnose also produced a typical pressure cushion.

The fungus overwinters as ordinary mycelium in the twigs. In the spring local patches of mycelium increase and form a tiny cushion, then the cells of this pressure cushion swell and rupture the bark immediately above the cushion. After this the cushion itself shrinks or is pushed aside,

Snow goose from the Wrangel Island colony at left, Canada goose from northwestern Canada at right. Some races of the Canada goose are larger than the snow goose. The blue geese and snow geese are genetic strains of the same species and may occur together in the same flocks. (Photo by Dr. H. C. Hanson.)

and below it the fungus mycelium produces a special structure that gives rise to the reproductive spores. These spores are formed and released in the spring when the leaves are just emerging from the bud.

Unlike the oak wilt fungus, the sycamore anthracnose fungus forms its pressure cushions within the tissues of the bark. Hence only the outer corky layer of the bark is broken. The pressure cushions formed by the sycamore anthracnose fungus are extremely minute, ranging from about 1/75 to 1/60 inches in diameter and from 1/200 to 1/100 inches high. This minuteness is undoubtedly the reason that these structures have been overlooked previously.

Of the thousands of different kinds of fungi known throughout the world, this is only the second instance in which the formation of this peculiar pressure cushion has been discovered. It is truly a peculiar feature.

Blues and Snows

It is now two years since Survey wildlife specialist H. C. Hanson enlisted the collaboration of Dr. R. L. Jones, soil mineralogist of the College of Agriculture, University of Illinois, in testing the possibility that minerals in the environment of breeding geese would be mirrored in the mineral content of the birds' feathers. Their confirmation of this correlation (*INHS Reports,* No. 42) makes possible the identification of the breeding area of any particular bird by clipping off some bits of feathers and analyzing them, because the nutrient chains of the various breeding grounds have quite distinctive mineral contents expressed as proportionate amounts of a dozen or so different mineral elements.

Since then, primarily in conjunction with Dr. Hanson's continent-wide study of Canada goose races, aided by support from the Guggenheim Foundation, this cooperative Survey-University team has assayed feathers from about 1,400 birds, using the information to check many aspects of Canada goose distribution and classification.

This year the same method was tested as a means of unscrambling a vexing problem concerning the blue goose and the snow goose. Although the large colonies of these

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geese are widely separated and occur across a wide stretch of the Arctic, most of the colonies comprise only one race. We therefore can not tell from a bird's appearance what part of the range it came from. Consequently when the half-million or more snow geese are south on the wintering grounds it is impossible to tell how many came from which breeding colony. Banding records indicated that there was considerable mixing on the wintering grounds, but the difficulties of banding and band recovery permit only an unreliable estimate of the extent of colony mixing.

Dr. Hanson obtained snow geese from two colonies in Canada, one on Southampton Island, the other at Cape Churchill, about 400 miles apart across Hudson Bay. In a chemical test of the wing feathers, birds from the two localities differed significantly in nine out of twelve minerals tested. So consistent were these values that they provide a means of identifying the respective colonies from which overwintering birds originated.

The importance of this "feather printing" was dramatically illustrated later in the year. Snow geese breeding on Wrangel Island, U.S.S.R., off the eastern tip of Siberia and those from Banks Island in the western Canadian Arctic winter together in California, about 130,000 birds coming from each source. Russian biologists, trying to insure the protection of the Wrangel Island flock and to re-establish colonies on the Siberian coast, have been especially concerned about the large numbers of these geese shot by hunters in California. Because of the inaccuracy of banding methods it has been extremely difficult to estimate how many birds came from each area and how many from each area were shot. Dr. Hanson and Dr. Jones assayed feathers from 15 geese banded in Russia and a number from the Canadian flocks. Their tests revealed clean-cut differences between these two major population groupings.

During these tests they also noted differences in the color and weight of feather ash from geese of the two populations. Comparable differences, which are much easier to determine than mineral content, occur between other populations.

These new findings may greatly simplify the problem of identifying breeding grounds of the geese and introduce entirely new concepts to the field of goose research and management.

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Skunks and Rabies

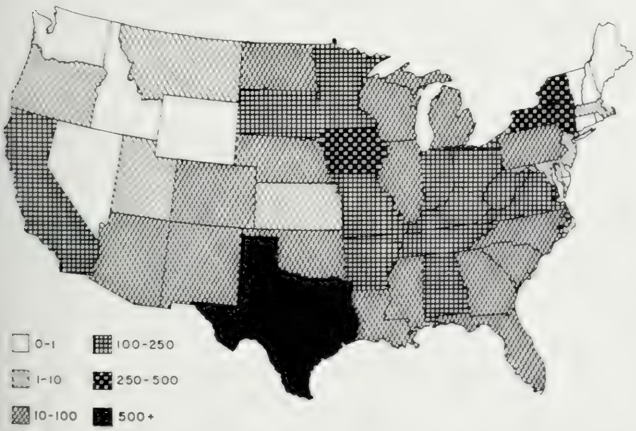
Tabulated data concerning the occurrence of rabies in wild and domestic animals for the United States have indicated that since the widespread vaccination of dogs, rabies is primarily a disease of wildlife. Outbreaks of rabies in domestic animals, chiefly dogs and cats, appear to have their roots in this wildlife reservoir of the disease. Analysis of the incidence of rabies in wildlife species has shown a remarkable correlation between prevalence of rabies in skunks with that in all other species of wildlife.

To test the degree of transmission of rabies among various species of Illinois mammals, in 1958 former Survey wildlife specialist B. J. Verts began sampling populations of the common wild species in northwestern Illinois. This part of the state was chosen because of the long history of rabies in skunks in neighboring Iowa and Wisconsin. Shimer College, Mount Carroll, Illinois, kindly provided space on their campus for a project headquarters.

By early 1959 it became apparent that random sampling of wild mammal populations would not give a clear-cut picture of the rabies story. It had become clear, however, that the disease was more prevalent in striped skunks than in any other species. Here another major difficulty was encountered. Too little was known of the life history and habits of the striped skunk to properly evaluate factors important in the epidemiology of a disease.

It is said that the epidemiologist does not worry about how a disease is transmitted when it is abundant. At that time it is usually obvious. The difficult problem is knowing how a disease is transmitted when it is at a low ebb and may not even be detected for considerable periods of time. Such is the case with rabies. Because of the association of skunks with the disease, Dr. Verts set about to test every possible means by which these animals might serve as carriers or reservoirs of the disease.

His investigation followed two main ave-



Relative abundance of rabies in the United States based on the average number of cases per year reported for each state, 1958-62. (After Verts, B.J., *The Biology of the Striped Skunk*, by permission of the University of Illinois Press.)

nues. One sought to establish the life history and habits of the skunk, including reproduction and population growth, any tendency of animals to clump together in the wild, the size of their hunting areas, and the number of times per day or per week that individual skunks might meet each other. He paid considerable attention to the development of various tissues in the animal, especially those concerned with the development of embryos.

The other phase of this study concerned the incidence of rabies not only in different animals but in different tissues of the animal. He found evidence that many skunks have rabies that is apparently in a latent state. He found some evidence that the latent disease may be transmitted from mother to offspring. There remain many questions for which Dr. Verts found only hints: How is the disease transmitted from mother to offspring? What stimulus converts the latent state of the disease to the active lethal type? But immense strides have been made in providing a sound basis for future scientific probing in this area of study. Dr. Verts' findings are embodied in the recent book *The Biology of the Striped Skunk,* published last month by the University of Illinois Press.

Venture Capital

In various phases of agriculture considerable use is made of a group of chemical organic molecules called chelating compounds. These substances have the ability to combine with certain metal elements such as calcium, iron, copper, or zinc and afford a means of transport for these metal ions. For example, a plant growing in iron-rich soil may nevertheless be suffering from iron deficiency because the iron in the soil is not soluble and cannot enter the plant. If the proper chelating compound is added to the soil, it will attach to atoms of iron and form a soluble compound that can enter the plant, carrying the iron with it.

Recently it has been noticed that some of these chelating compounds with metal ions attached disrupt the normal development of insects, frequently slowing down the rate of growth and sometimes stopping it, resulting in the death of the insects.

To assess them in relation to Illinois insect problems, Survey entomologist D. K. Sell is now testing a series of these metal-bearing chelating compounds on corn earworm larvae. He points out that we know little concerning the manner in which these compounds affect the physiology of the insects, nor do we know whether these compounds will ever be good insect control measures by themselves. There is an indication that some of them may enhance the toxicity of other chemical control agents, which might presage better insect control with lower insecticide dosages. Although the future for these chelating compounds as insect control agents is far from clear, they could eventually prove to be remarkably useful.

The Illinois Natural History Survey

In the 1850's, before the days of extensive federal investigation in biology and agriculture and before the advent of the land-grant colleges, the people of the Midwest realized that their expanding farm economy had to have a scientific base for continued development. One result of this demand was the founding in 1858 of the Natural History Society of Illinois, one of the first scientific institutions in Illinois to investigate problems of development of the state's renewable natural resources. Another scientific institution, the Office of the State Entomologist, was officially established in 1867 to combat losses inflicted by insects on the state's agriculture. In 1917 the continuing scientific bodies arising from these two organizations became incorporated into a single entity, the Illinois Natural History Survey.

The Natural History Survey and its two sister organizations, the Illinois Geological Survey and the Illinois Water Survey, are divisions of the State Department of Registration and Education, whose headquarters is in Springfield. The state legislature ruled that the three state scientific surveys be housed on the University of Illinois campus, in recognition of the cooperative relationships between the surveys and the University.

In 1858 Illinois was a sparsely settled agricultural state. Now it is populous,

The Survey chief and scientific section heads checking plans for the new Survey laboratory to be constructed at Urbana. *Seated*, center, George Sprugel, Jr., Chief; *standing*, left to right, section heads W. H. Luckmann (Economic Entomology), H. H. Ross (Faunistic Surveys and Insect Identification), G. W. Bennett (Aquatic Biology), J. C. Carter (Applied Botany and Plant Pathology), and G. C. Sanderson (Wildlife Research). (Photo by Survey photographer Wilmer Zehr.)

highly agriculturalized, industrialized, and urbanized. These changes have brought new problems concerning the integration of insect and plant pest control in relation to a changing farm technology and economy, to the maintenance of forest, city, and home plantings, and in the management of the state's alarmingly reduced natural resources having recreational values.

These changes have brought new problems regarding insect and plant pests, insects and human diseases, management of forests, the availability and use of game species for hunting and fishing, and the numbers and occurrence of other wildlife so dear to the naturalists and hikers of the State. Conditions in the State continue to change, and every change means a re-evaluation and re-orientation of the research activities of the Natural History Survey, in order to bring scientific knowledge to bear in solving new problems.

To acquaint Illinoisans with the Survey's activities, its technical editors, O. F. Glissendorf and R. M. Zewadski, working in cooperation with the scientific staff of the Survey, have prepared a short brochure of Survey activities that can be obtained on request. Also available is the Survey's *Centennial Volume*, published in 1958, outlining in greater detail the history, development, and activities of the Survey.

Pond Plants

Attempts to control "water weeds" in Illinois ponds and small lakes is bringing to light some interesting–but not wholly unexpected–information about the aquatic plants themselves. In the nearly ten years that Survey biochemist R. C. Hiltibran has been testing various herbicides for the control of unwanted aquatic vegetation he has been making notes on the principal species of plants in these bodies of water in different years and at different seasons. In some bodies of water, relatively few changes in type of vegetation have been noted, but in others the stands of aquatic plants have changed markedly.

An example of the latter is 5-acre Miller Pond in central Illinois. In 1960 northern milfoil covered 95 percent of the pond and only a few plants of sago pondweed were present. In 1961 a mixture of these two species infested about 70 percent of the pond acreage. Later in the summer two other plants, slender naiad and southern

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naiad, made their appearance. From 1962 through 1966 sago pondweed and southern naiad were the predominant water plants in the pond.

In Mansion Pond efforts to find a control for curlyleaf pondweed, covering almost the whole pond, finally reduced the curlyleaf drastically. When this had been accomplished, water horsetail or chara, which had previously been only a minor component of the pond vegetation, grew rapidly and practically took over the pond.

Comparable observations in other ponds indicate clearly that the pattern of pond vegetation in Illinois is a complex one and that changes in one component may set the stage for the spread of other species. Because all the plant species do not react the same way to specific control chemicals and do not reach maximum growth the same time of year, it will require much additional information to devise satisfactory year-round and year-to-year control measures for pond plants.

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Stormy Weather Ahead

Two dark clouds are beginning to gather over Illinois' cornfields, which have enjoyed remarkable freedom from insect losses for over a decade. These clouds are the increasing problems of two kinds of rootworms that feed on corn roots. These rootworms are not true worms but the larval stages of two kinds of small beetles. The female beetles lay eggs in soil, and these eggs hatch into the larvae or rootworms. When full-grown, these larvae pupate and change into the adult beetles. In Illinois there is only one generation per year.

The northern corn rootworm is a longtime Illinois resident, previously controlled easily by the chlorinated hydrocarbon insecticides such as aldrin or heptachlor. In recent years strains of this species have become resistant to these insecticides to the extent that phosphate and carbamate insecticides must now be used to control this pest.

The western corn rootworm is a relative newcomer to the Illinois scene. Forty or fifty years ago this insect was a rare museum curiosity known from the western Great Plains area. Thirty years ago it began increasing tremendously in the irrigated corn lands of central and western Nebraska and became abundant so rapidly that it devastated large corn acreages in that state. Since then this rootworm has moved eastward, the first Illinois specimen being found in Rock Island County in August 1964. Populations developed to economic levels in that vicinity during the next two years.

The western corn rootworm in Iowa and Nebraska had been found to be resistant to chlorinated hydrocarbon insecticides; Survey entomologist R. E. Sechriest tested the Illinois populations and verified the fact that this was true also of the immigrant populations established in this state. It was realized then that when and if the western corn rootworm became abundant in Illinois, it would also have to be controlled by phosphate and carbamate insecticides.

That time has now arrived. Last summer Dr. Sechriest and his fellow entomologists W. L. Howe and D. E. Kuhlman found high western corn rootworm populations and associated heavy damage in cornfields in the northwestern one-fifth of Illinois, bounded roughly by U.S. Route 51 to the east and U.S. 24 to the south. In past years northern corn rootworms have been a perennial problem only in the northern half of Illinois. Whether or not the western corn rootworm will eventually spread into more southern areas is yet purely a matter of conjecture.

Roots of corn plants. *Left,* almost completely destroyed by corn rootworms; *middle and right,* luxuriant root growth on plants protected by insecticides. When the roots are destroyed as much as in the example to the left, the corn plant is extremely susceptible to lodging. (Photo by Dr. Sechriest.)

Both species produce the same symptoms. They eat off the roots of the corn plant and, if abundant, leave the plant with practically no anchor in the soil. When this happens the slightest wind will lay the entire cornfield flat so that the corn is extremely difficult to harvest. Even the ears that are obtained are far smaller than normal with a usual reduction in yield of at least 50 percent.

There is another disturbing factor on the horizon. Dr. Sechriest points out that some resistance to the phosphate and carbamate insecticides has already been observed in a few insect species. The entomologists feel that it is only a matter of time until both corn rootworms will evolve strains resistant to these insecticides also. This situation requires a hard look at still other means of controlling these tiny insects. In an effort to prepare for such an eventuality, Dr. Howe is undertaking an intensive series of life history studies aimed at delving into the habits of these beetles, hoping to find a chink in their biological armor that we can exploit as a control measure.

The Eyes Have It

In the study of many aspects of cottontail rabbit biology, one of the most difficult pieces of information to acquire has been the age of individual rabbits. This information is especially important in determining the distribution of various ages in the population structure, the age at which various diseases or parasites may occur in the animals, the age of first reproduction, and many other bits of information that contribute to a knowledge of the rise and fall of population numbers.

In 1959 former Survey wildlife specialist Rex Lord discovered that there was a definite relationship between the age of a freshly shot rabbit and the dry weight of the lenses of its eyes. By referring to Dr. Lord's chart it was possible to approximate the age of a rabbit from the weight of eye lenses. These data were converted to a mathematical formula, but considerable calculating was still necessary to derive age from lens weight.

In an effort to reach an easier and surer age estimation, Survey wildlife specialist W. R. Edwards converted the mathematical equation into a simple table so that one can weigh the lens and read off the age in days. For convenience he also prepared a table for converting estimated age in days to the birth dates of cottontails.

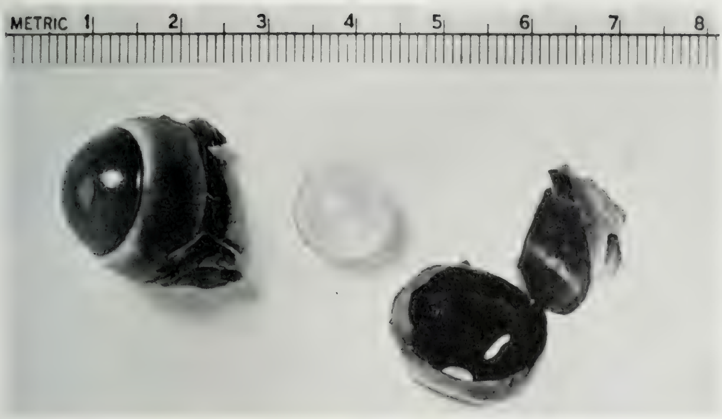
In checking a large number of eyeballs of known age, he found several points that need to be considered in using this aging technique. It seems to work with accuracy for only the first year of the rabbit's life. After that the relationship between lens weight and age is not precise.

On another point, frequently the two lenses gives slightly different weights, and it has been difficult to know which one to use or whether to use an average for the age estimate. Survey studies indicate that normally the two lenses of a rabbit are almost exactly the same weight and that the difference in weight between lenses of a pair is primarily the result of sloughing of tissue of one or both lenses during handling. From this it is evident that the heavier lens should be used for estimating age.

This latter result has led to a re-examination of the procedures to be used in removing the lens from the socket and preparing it for weighing. These hints and the tables for estimating ages and birth dates of cottontail rabbits are contained in the recently issued *Biological Notes No. 59,* which may be obtained by writing to the Survey.

The Brown Recluse Spider

As evidence of continued spread of the brown recluse spider appears in the Illinois press, state residents are becoming more and more apprehensive concerning this little animal. Almost daily Survey entomologist J. D. Unzicker receives batches of spiders suspected of being this species and about half of them are. To date, however, there are no records of anyone in Illinois having been bitten by the spider. Both male and female spiders can inflict poisonous bites. The venom attacks the cells of the skin and flesh, producing relatively large wounds that are painful and slow to heal, usually resulting in a small area of necrotic tissue that eventually sloughs off. Only rarely is the bite fatal.



At *left*, entire cottontail rabbit eye dissected from animal; *center*, lens dissected from eye; at *right*, eye socket from which lens was extracted. Numbers on scale refer to centimeters (2.5 centimeters equals about one inch). (Photo by Survey photographer Wilmer Zehr.)

First reports of the spider in Illinois came from the southern part of the state in 1957. The spider is now widespread in the central and southern part of the state with occasional records to the north. In Illinois this denizen of the deep south cannot survive outdoors in winter, but it readily moves into heated buildings when cold weather arrives and survives in these protected situations. The brown recluse is a shy spider that likes dark corners and nooks in attics, closets, storerooms, and barns, and especially likes to hide in clothing and bedding. It is this habit that most often brings it into contact with humans.

From 1957 to 1966 only occasional specimens of this spider were encountered, but during the last year Dr. Unzicker and others have discovered large populations of the spider containing males, females, and young, prime evidence that the spider has become well established and is breeding in at least the southern half of the state. Because of its propensity to spend the winter in dwellings, the brown recluse will undoubtedly become a permanent resident throughout Illinois. Anyone concerned about the spider can obtain additional information and illustrations of diagnostic characters by writing to the Survey.

Tree Talk

When one mentions protection of plants, first to come to mind are the agricultural crops that produce the annual harvests on which farmers, gardeners, and nurserymen depend for their economic operation. Yet there is another important type of plant that has just as many problems and requires as much care and protection. This type includes the trees in our gardens, streets, and parks that provide shade and beauty beloved by all.

Perhaps because we tend to avoid putting dollar appraisals on aesthetic values, concerted interest in the protection of shade trees was slow to start. But when introduced pests and diseases such as the gypsy moth and the chestnut blight caused full-scale ravages of shade trees in the eastern United States, and it became apparent that the replacement cost of these plants was enormous. It is a simple matter to replace a sickly peony in your flower bed with a healthy one of the same size, but it is almost impossible to replace a large dead elm tree in your lawn with another live, healthy elm tree or any other tree of comparable size. Because of the several years required to grow large numbers of trees in experimental plots, testing remedies and cures for tree problems requires much time and space.

Realizing that the greatest progress in solving tree problems would come from a pooling of everyone's information, in 1924 arborists, nurserymen, botanists, horticulturists, entomologists, foresters, and others interested in tree protection organized the National Shade Tree Conference. Holding meetings annually, this organization provided a much needed base for shade tree enthusiasts of all types to share discoveries and organize attacks on unsolved problems.

So successful was this conference that in 1946 a midwestern chapter was formed to give additional emphasis to regional shade-tree problems. Comprising twelve states

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bordered by Illinois and Wisconsin to the east, Colorado and the Dakotas to the west, and Oklahoma and Arkansas to the south, the Midwestern Chapter has blossomed into a valuable forum for over 500 participating members.

For many years Survey botanists have been active in this organization and plant pathologists J. C. Carter, E. B. Himelick, and Dan Neely have contributed especially to problems concerned with shade tree diseases and their control. Dr. Carter was one of the organizers of the Midwestern Chapter and was its president in 1948. In 1961, when Dr. Carter was its president, the National Shade Tree Conference enlarged its scope to include participants from Canada and other countries and became the International Shade Tree Conference.

Survey botanists are just now home from the Twenty-third Annual Convention of the Midwestern Chapter, held in St. Louis, Missouri. During the three-day program over 30 experts discussed shade tree problems ranging from pruning and transplanting, pest control, and selection of varieties, to the business aspects of arboriculture.

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MARCH 1968, NO. 65

Thrush Flights

Nearly three years of data have now accumulated since the historic flight of the Swainson's thrush from Urbana, Illinois, to Rochester, Minnesota. The flight was tracked by Survey wildlife specialist R. R. Graber on May 6, 1965. The bird was carrying a minute radio transmitter designed by Survey electronics engineer W. W. Cochran. When the bird took off after dark Dr. Graber followed it in a plane carrying special detection equipment and for the first time was able to get accurate information on the speed and direction of migrating song birds (INHS Reports 32).

Since then Cochran has continued the studies, and 22 migratory flights of the Swainson's thrush, grey-cheeked thrush, and Veery have been followed various distances from Urbana, sometimes by plane and sometimes by truck, both equipped to detect the *beep-beep-beep* emitted by the tiny radio transmitter attached to a bird.

All three species of these thrushes winter in South America or Central America and each spring wing their way north to breeding areas in boreal North America. Large numbers of them pass through Illinois and are present in the state for a few weeks in May. The Survey ornithologists trap and identify a bird, attach a tiny transmitter under some of the back feathers, release it, then wait for it to resume its migratory flight. After this they follow it by air or truck as far as possible.

Such studies have yielded considerable information about spring thrush migration. The migration is entirely nocturnal, usually commencing one or two hours after sunset and ending at dawn. When landing in darkness, these migrants do not select their typical habitats but instead wait until light to find such spots. On long flights the birds fly at altitudes of 2,000 to 6,000 feet. At least some individuals are capable of migrating on two successive nights. Air speed is usually less than ground speed, suggesting that the migrants are often aided by the wind. There is considerable variation, but most flights are at air speeds between 25 and 35 mph.

The variability in directional heading is also quite large, but gray-cheeked thrushes seem to head more directly north while

A radio-tagged thrush. Feathers almost completely cover the transmitter, from which protrudes a 12-inch music wire antenna, its first 2 inches covered with a thin, white plastic sleeve. (Photo by W. W. Cochran.)

Swainson's thrushes head northwest. There is some indication that the migrants select a definite heading even when departing under overcast skies, but to do so probably requires clear or only partially cloudy skies during the day or evening prior to departure. Straight flights are maintained for a hundred or more miles under overcast.

A few of the birds flew in directions other than north. These reverse flights are difficult to explain. Shorter reverse flights may be local wandering between sustained migratory flights and others may be due to a change from warm to cold weather.

An item of special interest appeared to be a lack of ground orientation during most of the flights. Except for large topographic features, of which Lake Michigan was the only one noted, these birds appear to fly by dead reckoning rather than by following a succession of ground clues.

Promising Combination

An ever present problem in the management of bluegills for fishing, especially in a relatively large body of water such as Ridge Lake in Coles County is the innate tendency of bluegills to build up tremendous populations resulting in small and stunted fish. Theoretically introducing a predator species such as bass should help take care of this situation by removing large numbers of small bluegills. In small farm ponds that can be drained and restocked easily whenever populations get out of hand, this bass-bluegill combination often works well for a few years.

In an effort to effect drastic reduction of bluegill numbers without resorting to the tremendous task of draining and restocking, Survey aquatic biologist G. W. Bennett and his colleagues tried lowering the level of Ridge Lake each autumn, thus reducing the fish population to a water volume only one-third that of the full lake and presumably increasing the predation on the smaller bluegills by the bass. The drawdowns did indeed appear to be an easy method for controlling bluegill numbers and preventing the development of an over population of the species in Ridge Lake. Following the drawdowns the average size of bluegills caught by fishermen increased and the ratio of large to small individuals also increased, until fish more than 6 inches long predominated. In spite of the increase in total length, however, the bluegills were still not satisfactory pan fish — they were too thin. It appeared that Ridge Lake did not have an environment that produced robust bluegills.

Laboratory studies in feeding bluegills various experimental diets suggested a method for improving plumpness of bluegills in Ridge Lake. To test this Dr. Bennett and his colleague H. W. Adkins began distributing a commercial pelleted food in areas of the lake where bluegills were most numerous. The fish soon learned to eat these additives. Feeding was begun when the water temperature reached 60 degrees, usually in May, and continued through August, after which the drawdown was begun. The fish were fed twice each day at 10:30 a.m. and 7:00 p.m. by broadcasting the fish food pellets by hand from a boat. On the basis of the total area of the lake about 2 pounds per acre per day was applied, or about 3,000 pounds to the whole lake for the entire season (*INHS Reports 45*). This program of feeding plus drawdowns continued through the seasons of 1965, 1966, and 1967.

Two things are immediately apparent from a comparison of bluegill fishing results in Ridge Lake over the past 15 years. First, during the 3-year period of feeding and drawdowns, the total yield of bluegills has climbed to its highest point, about 80 pounds per acre. Second, the average weight of the bluegills has likewise reached its highest point, and individual fish averaged nearly twice as heavy as in the best prefeeding season. Fishermen have even caught a few bluegills that exceeded a pound in weight.

On the basis of the 1965-1967 results, it begins to look as if the combination of drawdowns plus feeding may be the answer to improving bluegill fishing in bodies of water such as Ridge Lake.

No-season Year

In Illinois and other moderately high latitude areas entomologists have a terrible time keeping various insects alive and active during the winter. Yet winter is the time of year when the entomologists have

Cabinet-type growth chamber in which alfalfa weevils are reared continuously, independent of outdoor season. Settings for desired temperature, humidity, and light cycle and intensity are made on the control panel to the left. Dr. Armbrust is examining a dish of weevil eggs to record hatching. (Photo by Survey Photographer Wilmer Zehr.)

the greatest amount of time for concentrated investigations concerning the application of new ideas for the control of these species.

A great number of our insects such as the European corn borer, corn earworm, and alfalfa weevil, have inherent, automatic, built-in physiological mechanisms that bring about a cessation of activity when winter approaches, and these mechanisms keep the insects dormant through the winter until the start of the next growing season. It might be supposed that low temperature was the stimulus that triggered the dormant condition, but in most insects this is not the case. Frequently the "trigger" is the increasing amount of light striking the immature stages. Typically if the young are subjected to long hours of daylight, as in early summer, the adults into which they transform will become dormant no matter what other conditions may be. If these dormant adults are brought into the laboratory they must be subjected to long periods of cold before they again become active. For certain species in which dormancy is not a problem, other environmental conditions make laboratory rearing difficult.

In order to maintain cultures of active normal insects for experimentation during all months of the year, Survey entomologists have to trick these species into acting continuously as if they were in the natural growing part of their cycle. They do this by maintaining the insect cultures in growth chambers in which light intensity and duration, temperature, and humidity can be maintained at any desired values.

These chambers range from cabinet types about the size of a small refrigerator to walk-in models that are almost a small room. Various conditions within the chamber are provided by a combination of lights, heaters, refrigerating units, fans, water sprays and dehumidifiers, each under exact control by sensing elements within the chamber. Almost any desired condition can be maintained by an appropriate setting of controls. With this arrangement and with a knowledge of the critical factors necessary for keeping each species active, it is possible to maintain cultures of numerous species in their active stage throughout the year.

Because each species has different environmental requirements, only one species can be raised at one time in each chamber. Dr. D. B. Broersma finds that his tarnished plant bugs are moderately easy to rear except that when the light gets below 14 hours a day, the females stop laying eggs. Thus light of this duration must be supplied every day. Dr. E. J. Armbrust and his colleague C. E. White have great difficulty maintaining cultures of the alfalfa weevil. If the larval stage is exposed to more than 8 hours of light per day, the resulting adults will become dormant, and only one generation per year will be produced. If the lighting is kept on the short cycle, four generations per year can be obtained, allowing year-round experimentation. Even so, extreme caution must be taken to keep the relative humidity below 60 percent; under more humid conditions the culture dies. Dr. J. V. Maddox and D. K. Sell find that light values are important to prevent European corn borer and corn earworm cultures from entering dor-

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mancy. The corn earworm further requires low light intensity resembling moonlight for mating, hence periodically the lights must be turned very low.

Difficulties arise also with the plant hosts. Dr. Broersma has found that his soybeans in the growth chamber need 4,500 to 5,000 foot-candles of light for 16 hours a day in order to grow as luxuriantly in the chamber as they do under field conditions. At lower light values the plants become scraggly and pale, conditions that may introduce variables into tarnished plant bug survival other than the simulated climatic conditions.

These growth chambers are costly but are providing present-day investigators with opportunities for investigation that did not exist only a short time ago.

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Before and Now

In today's mounting concern over pollution of our environment, the scientist is faced with a difficult question: How can we assess changes in the environment that have already occurred?

Because of the early importance of fisheries in the state's economy, and because the biological degradation of the rivers became apparent early in the century, intensive studies of aquatic organisms in the state date back into the last century. Here we have a firm record by which to compare the aquatic life of the earlier times with that of today. Sports fishing in Illinois waterways has kept active this interest in aquatic life. Drastic decline of the fantastic hunting afforded by the formerly immense waterfowl resources associated with Illinois waterways also focused attention on the need for following the changes in the aquatic environment.

As concern about pollution turns to its effect on land life, we encounter a different picture. After the larger game animals were gone, changes in the land fauna have seldom been conspicuous, but there is every reason to believe that they have been drastic. Figures on land use indicate great shifts in the last 70 years in the intensity of cultivation, reduction of woodland areas, rigorous draining, and increased use of agricultural chemicals such as fertilizers, insecticides, and weed killers.

Studies in Europe demonstrate that comparable changes have been accompanied by as high as a 50 percent decrease in many kinds of insects, notably species

A wild bee belonging to the genus *Halictus* gathering nectar and pollen from strawberry blossom. (Photo by Dr. E. R. Jaycox, University of Illinois.)

that are beneficial to man as either pollinators of flowering plants or predators and parasites of other insects. The basis for the European figures lies in the extensive collections of insects and other animal groups made by naturalists over the last 200 years. These older collected specimens are housed in European museums and are still available for study.

Few situations of this sort occur in North America. Survey entomologist W. E. LaBerge points out that one of the most promising leads in the study of detailed changes in land life associated with Illinois land use is the bee fauna of Macoupin County. Mr. Charles Robertson, a long time resident of Carlinville, collected, identified, and described 296 species of bees from Macoupin County for the period 1890 to near 1920. He carefully recorded the flowers visited by these thousands of bees and unquestionably accumulated virtually every species of bee occurring in the region at that time. The entire Robertson collection was deposited with the Illinois Natural History Survey and is available for study and comparison.

Dr. LaBerge, a bee specialist of world renown, has begun a restudy of the bees of Macoupin County. To achieve the thoroughness of the Robertson bee survey, this endeavor will need to be pursued intensively for several years. Because of many changes in bee classification since Robertson's time, his published records alone would not be an accurate basis for comparison. But because his actual specimens are available for restudy, the comparison can be made with great fidelity. When plotted against recorded changes in land use in Macoupin County, these bee studies should furnish us with reliable information on key changes in land faunas in the last half century.

Progress Report on Glads

Tracking down the cause and a possible cure for the virus-produced white break disease of gladioli is proving to be a long and tortuous road. This is not unusual — it is typical of efforts to understand most virus problems in plants as well as in animals.

White break is manifested as white streaks on the gladiolus flowers, especially noticeable on darker colored varieties. It is always present to some extent in the gladiolus-growing areas of east-central Illinois and at times occurs in outbreak proportions (INHS Reports 32).

After their first 3 years of experimentation with white break, Survey plant pathologists J. L. Forsberg and Walter Hartstirn are far from a solution to the problem but have some promising bits of information.

In their first experiments they tagged diseased gladiolus plants and planted their corms separately the next year. Almost all of these corms developed diseased plants. In field plots from which diseased plants had been carefully weeded out, the incidence of white break did not rise, but the disease did not disappear. It is evident from this that eliminating diseased stock will keep the disease at a low level.

In conducting these experiments, it was necessary to place plots on several gladiolus farms. During the 1965 season there was more white break on some farms than on others, indicating the possibility that certain locations might be "hot spots" for the disease. To test this, gladiolus varieties known to be highly susceptible to white break were obtained from a single source and samples of this stock were planted in each of the five fields where variation in disease intensity had been noted. In both 1966 and 1967 the amount of white break in these stocks was essentially the same on all five farms. The greatest distance between any of these farms was less than 5 miles, hence it seems likely that the spread of white break is rather uniform throughout the eastern Illinois gladiolus-growing area.

In each experiment the various samples of corms were divided into two lots, one lot planted in early May, the other in late June. The May plantings matured and were harvested several weeks earlier than the June plantings. In every instance the incidence of white break was greater in the June plantings than in the earlier ones. This gives the first clue to the possible vectors of the disease. A wide variety of

The keen senses of trained bird dogs are required for an accurate quail census in a field like this. In this picture the rear dog has stopped short to honor the other dog's point. (Photo by former Survey wildlife specialist Dr. R. E. Yeatter.)

insects, especially aphids, emerge and migrate in great numbers in middle and late summer. The heavy incidence of the disease in late plantings, coupled with the apparent uniform general occurrence throughout the area, suggests strongly that some of these middle and late summer insects transmit the disease from plant to plant.

Seasonal Reminders

All through the winter the many insects that plagued farmers, gardeners, arborists, and householders have persisted with the tenacity of their kind, either in a hardy stage in Illinois, in warm spots provided by human habitations, or in the sunny climes of the southland, from which some of them reinvade the Midwest every spring. It is safe to predict that Illinoisans will have their share of troubles with insects this coming year as in past ones.

To give the people of the state advance guidance in insect control problems, Survey entomologist H. B. Petty and his colleagues have already prepared their "1968 Suggested Insecticide Guides" for insect control on field crops, commercial vegetable crops, greenhouse vegetables, livestock, and in the household. Prepared cooperatively by the Illinois Natural History Survey and the University of Illinois College of Agriculture, these Circulars 897-900 follow much the same pattern as last year's editions except in the area of field crops. In this category trends to early corn planting and the greatly increased resistance to certain insecticides in corn rootworms may necessitate considerable change compared with last year. Soybean and dairy farms are again definitely on the "no chlorinated-hydrocarbon insecticide" list.

Dr. Petty and his group are also continuing the *Insect Survey Bulletin*. The subscription has had to be raised from $2.00 to $3.00 because the authors plan to average four more issues per year and because postal rates have increased. This publication may be ordered by addressing your request to "Insect Survey Bulletin, 122 Mumford Hall, University of Illinois, Urbana, Illinois 61801."

This is the time to remember that ticks and chiggers will again be a problem for hikers and out-of-door enthusiasts. More information about ticks and chiggers and methods of avoidance and control can be obtained by writing to the Survey.

Good luck!

Statistics, Dogs, and Quail

In areas that are being managed for quail hunting, two questions are often difficult to resolve. First, is the entire area being planted and maintained so that all parts of it are suitable for high quail populations? Second, is the quail population itself at as high a level as might be expected?

In an effort to resolve these questions,

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Survey wildlife specialists J. A. Ellis, R. L. Westemeier and K. P. Thomas have been conducting an analysis of quail abundance and distribution on a 275-acre portion of the Sam Dale Lake Conservation Area in Wayne County. This state-owned area is currently being managed for quail by the Illinois Department of Conservation. The wildlife researchers periodically census the quail on the area, count the number of birds per covey and the number of coveys per square mile, and locate each covey on a detailed map so that they can determine the distance between each covey and the nearest neighboring covey.

According to certain statistical models, if the coveys are clumped in certain parts of the area rather than being scattered over it, only that part with the clumped coveys is suitable quail habitat. If the number of coveys is low, they should show a random, hit-and-miss distribution where habitat conditions are uniform. If the covey numbers are high, they should show a relatively uniform spacing forming roughly a hexagonal pattern as a result of social competition among coveys.

The first tests in the Sam Dale Lake area raised some interesting questions. The coveys were distributed relatively uniformly in the fall when their numbers were high and even more uniformly in spring when their numbers were low. This seems to indicate that, no matter what the density of the coveys, the behavior of the quail is antagonistic between coveys and their distribution tends towards uniformity rather than randomness.

The reliability of population studies of this type depends on the accuracy of the census. This is where the dogs come in. The backbone of the quail censusing operation is the team of highly trained hunting dogs who can locate and point quail in a field with a speed and accuracy that could never be matched by the research worker alone. It is a strange paradox that in so many wildlife studies statistics and the computer rely on data made available by man's best friend.

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MAY 1968, NO. 67

Two for the Price of One

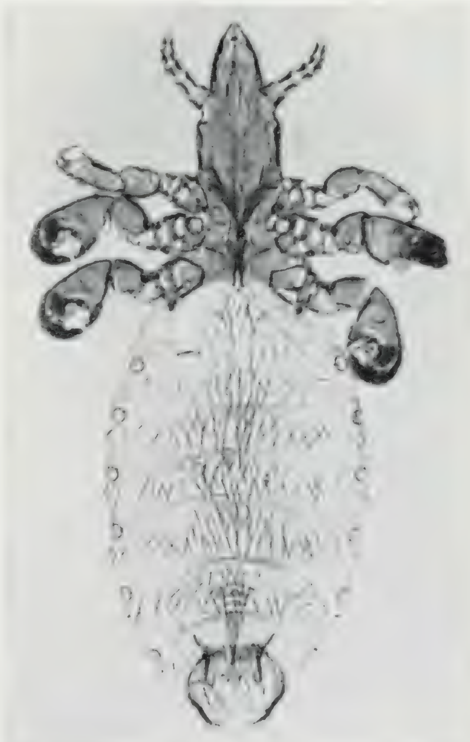
Among insects, lice have many peculiarities. They are the only insects that spend all their lives, egg through adult, on their hosts. By contrast, only adult fleas attack their hosts, the free larvae living in the host's lair. In kedflies, which are viviparous, the full grown larvae drop to the ground for pupation.

The sucking lice, collectively called the Anoplura, occur only on mammals. These have clawlike legs with which they cling to mammal hair and mouthparts consisting of an extensile set of slender stylets (much like those of a mosquito) that are inserted into the host tissues for feeding.

Only a few hundred species of sucking lice — including the human louse or cootie — are known to exist. Although rare in species compared with beetles, of which nearly a quarter of a million different kinds have been recognized, the sucking lice can be extremely important from the standpoint of human success. The cootie, for example, transmits typhus and is credited with being the real cause of Napoleon's downfall in his Russian campaign and the real victor in many other northern military episodes.

In eastern North America four members of this group claim a steady toll from the cattle and dairy industries. In Illinois the long-nosed louse, the short-nosed louse, and the little red louse are the major species found on our domestic cow. A fourth, the large cattle louse, known from Florida, has not yet been found in the state.

Survey entomologist Stevenson Moore reports that prior to the middle 1950's these cattle lice were sufficiently abundant in Illinois to cause cattle marked discomfort and nervousness, resulting in losses of both milk and meat production. At that time 80 percent of Illinois beef and dairy herds were badly infested, producing an economic problem in 20 percent of the beef herds and 10 percent of the dairy herds. Control of the lice was difficult because application methods were laborious and insecticides that could be used on beef



Linognathus vituli, the long-nosed cattle louse. Actual length 3/16 inch. (Photo by Survey photographer Wilmer Zehr.)

and dairy animals were relatively ineffective.

In the middle fifties more effective insecticides were discovered and Survey entomologist W. N. Bruce invented a treadle self-spray machine, primarily to control horn flies, stable flies, and face flies. The cattle took to these new appliances readily and rapidly. Fly infestations dropped and meat and dairy production rose dramatically.

In his last census, entomologist Moore found that the louse population had also been controlled to a remarkable degree. He found no sign of lice in 22 dairy herds and only light populations of lice in about half of the beef herds. He attributes the infestation in the beef herds to the fact that new feeder animals are continuously added to these herds and the newcomers bring some lice with them. A remarkable fact is that these new imported infestations do not build up but are continuously reduced by summer sprays for flies. Because the dairy herds have only infrequent replacements, the fly sprays apparently keep the lice completely cleaned out.

Is It Really Winter Killed?

This spring, residents of Illinois have discovered that many of their favorite vines and shrubs have failed to leaf out or been killed back to almost the ground line. Climbing roses and privets are especially common victims. A large number of trees are showing some dieback of branches, and yews and junipers are showing conspicuous browning. The symptoms and timing indicate winter injury as the cause of damage.

In assessing this situation, Survey plant pathologist D. F. Schoeneweiss points out that in east-central Illinois much of the damage now visible had its cause last summer. In this area, the period from June to September was very dry. The rainfall was only two-thirds the normal amount, and for many periods of several weeks there was no rain at all. If susceptible plants are not watered during these periods, part of the root system may die, producing on deciduous species an early leaf drop that does not appear serious. Plants so injured may not leafout at all the next spring or may have extensive dieback of many of the branches, no matter what the winter was like.

Dr. Schoeneweiss further points out that, last summer conditions appear to have been ideal for many insects' attacking ornamentals. Especially abundant were species of scale insects on Euonymus and lilacs. Some of these infestations were severe enough to cause leaf drop and would undoubtedly cause the plant to enter winter dormancy in a weakened condition.

Winter injury itself undoubtedly occurs in plants no matter how good their condition, but here again the action of cold weather may not be what we think. If the temperature is lowered very slowly, most plants will withstand below zero weather quite successfully. If, on the other hand, there is a very sudden drop from considerably above freezing to considerably below freezing, such a drop will injure many plants that would survive a slower fall in temperature. East-central Illinois had such a sudden drop between Christmas and New Year's Day, and this could have caused much plant damage.

Summing up the various factors involved, winter kill may have been the final factor in the demise of the plants, but in our east-central area the chances are very good that this would not have happened to nearly such a great extent if many of the plants had not been weakened previously by either last summer's drought or last summer's insect attack.

Cannon-Netting Deer

Catching deer for experimental purposes has proven a tricky business because many of the methods used may injure or kill a large porportion of the animals that are captured. In an attempt to find an improvement that would trap these wary animals without injuring them, Survey wildlife specialist G. C. Sanderson and his assistants R. E. Hawkins, L. D. Martoglio, and G. G. Montgomery tried to adapt a cannon-powered net trap for use on deer. The trap had previously been used to capture wild birds.

Wildlifers Montgomery and Hawkins preparing to fold net used in deer capture. (Photo by Survey Photographer Wilmer Zehr.)

In their initial experiments they used a nylon net 60 x 40 feet with a 3-foot fringe around the periphery. In preparation for a capture, the net was folded into accordion pleats along one side of a field. Three rocket-like cannons were mounted about 4 or 5 feet off the ground and tied to the ends and center of the net. The cannons were fitted with electrical discharges so they would fire in unison.

This arrangement of net and cannon was set up along an area that had been baited for deer. When deer visited the baited area in the evening, the cannon trigger was pulled either by a hidden watcher or tripped by the deer themselves when feeding. When the cannons fired, they shot over the heads of the deer, pulling the net with them. The net fell on the animals beneath, and the team of wildlifers immediately rushed in and tied the animals caught under the net.

In the initial series of experiments 18 shots averaged two deer each. None of these deer was injured by the netting capture itself, but two of the buck deer died later from injuries incurred in their efforts to escape. The success of these preliminary tests indicates that cannon-netting may become a useful tool in deer research.

Test Stream

The many small streams that wind their way through the Illinois landscape are a potential source of great recreational value. Many if not most of them receive city sewage and flow through agricultural land. Both of these factors change the character of the stream drastically. The sewage adds large amounts of organic material to the water, and the agricultural land adds silt and various chemicals at times of heavy rain. The question is: How much sewage and silt can such streams carry and still be a recreational resource?

To get basic information on this question the Natural History Survey, the Water Survey, and the University of Illinois Department of Civil Engineering are working together on a study of the Salt Fork River from Urbana to Homer, on the east edge of Champaign County, with supplemental observations on the branch of the river arising at Rantoul and joining the Urbana branch at St. Joseph. The headwaters of the Urbana branch arising about 12 miles north of the city have clear, clean water and an abundance of life. At the Urbana-Champaign sewage treatment outlet there is a sharp change. Here occur only a limited number of aquatic organisms that are unusually tolerant of low oxygen content. Fish are absent. In the 20-mile stretch between Urbana and Homer the fauna of the river gradually becomes more diverse and tends to approach that of an unpolluted stream.

Before the sewage disposal plant was installed, Urbana and Champaign emptied raw sewage into the river and, as the cities grew, the river came to be little more than an open sewer. Former Survey entomologist C. P. Alexander surveyed much of the river fauna between Urbana and Homer in 1921 and found that for at least 10 miles below the sewer openings in Urbana the river classified as septic, practically synonymous with lifeless. When the sewage

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treatment plant was put into operation a few years later conditions improved markedly, but as this plant is now approaching its capacity of handling 14 million gallons of sewage per day, conditions are again worsening. Survey aquatic biologist R. W. Larimore points out that this is especially true in periods of low water during the later summer months when the sewage effluent comprises four-fifths of the stream flow.

In the present study the Water Survey and the Department of Civil Engineering are especially interested in physical and chemical properties associated with the effluent and its dissipation downstream. Their personnel are concentrating on the rate of oxygen replenishment in the water, the production of oxygen by photosynthetic organisms living in the water, and levels of phosphate, nitrate, chlorine, carbon dioxide, and other compounds. The Natural History Survey team, composed of Dr. Larimore, W. U. Brigham, and Allison Roeske, is attempting to correlate the animal fauna. Mr. Brigham is making intensive studies in the Urbana branch and the main river from St. Joseph to Homer, Miss Roeske is making a special study of the 14-mile Rantoul branch.

As cities on all Illinois' small streams continue to grow, small stream problems will become more and more important from both a health and a recreational standpoint. The results of this Salt Fork study should have a wide application.

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JUNE 1968, NO. 68

Insect Chemosterilants

Ever since the screwworm fly was eradicated from Florida by introducing enormous numbers of previously sterilized but still vigorous male flies into field populations, entomologists have been intrigued with the method as a possibility of not only reducing but actually eliminating injurious species of insects. Theoretically the method would be most successful if the insect populations occurred in somewhat isolated localities and if the females were monogamous, that is, if they mated only once.

In casting about for a trial species that would fill these conditions, Survey entomologists R. D. Pausch and Stevenson Moore decided that the housefly was an excellent possibility. Working with the fly in the laboratory, Dr. Pausch verified that it was indeed monogamous. In the present Illinois farming economy, large populations of the fly occur chiefly around dairy farms and feed lots, where the immature stages of the fly (small cylindrical white maggots) live in the animal excrement. Although not rigidly restricted to such farms, intervening populations of houseflies seem to be relatively low. On these grounds the housefly gives every indication of being a good potential test species.

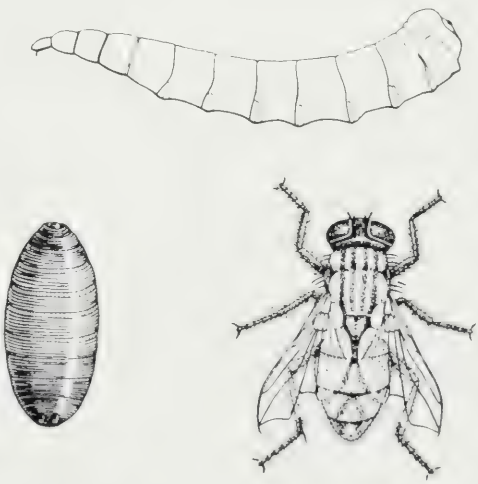
The next step was to find a sterilant that, at the proper dosage, would produce sterility in the male without reducing its vigor or sexual competitiveness with other males. Eighteen were tested; three gave excellent results. A syrupy bait containing 0.5 percent of the sterilant produced male sterility without reducing vigor. Dr. Pausch tried various devices for presenting the bait to the flies and finally found that knitting yarn soaked up with the bait and hung from the ceiling seemed to give the best results.

There was some concern as to how long the baits would be effective. Another series of tests indicate that they will continue to sterilize the flies for at least three months. The problem will therefore be replenishing the bait in the yarn if the flies eat it all.

This summer the entomologists have enlisted the aid of two beef farmers, one dairy farmer, and one poultry farmer in east central Illinois in testing this insect sterilant program under field conditions for the control of houseflies. As one of their colleagues has said, the plan should work if they can ever get the "bugs" worked out of it.

Production Puzzle

Every year that the fish produced in the nine 1-acre experimental ponds at



The larva or maggot, puparium or transformation stage, and adult of the housefly. Length of adult 0.2 inches. (Drawing by Alice Ann Prickett.)

Forbes State Park are weighed, the more complex becomes the problem of comparing and predicting fish production. Before these ponds were built, small pond experiments designed to compare and test fish management practices gave conflicting results. It was thought that one of the chief reasons for discrepancies was the use of experimental ponds of different types and sizes, such as strip-mine ponds, borrow pits, farm ponds, and small impoundments. These ponds were used by necessity rather than choice because of the high cost of constructing and maintaining large numbers of essentially identical ponds in the same place.

When the Department of Conservation constructed nine 1-acre ponds for the Survey's use in Forbes State Park, Marion County, Survey aquatic biologists G. W. Bennett and D. H. Buck decided first to test the relative fish production of the ponds. Each was stocked with the same number of the same kind of fish, in this case carp fry. Here side by side were nine ponds on the same soil type, with the same climate, the same initial fish population, the same water source, and the same amount and kind of fertilizer. When fish production was measured at the end of a summer growing season, the range of production per pond was amazing, ranging from 177 to 335 pounds each; in other words, the best pond produced almost twice as many pounds of fish as the poorest, with different ponds forming a graduated series in between.

So surprising were these results that the identical experiment was repeated in 1965 and 1966, with no fertilizer added. In both 1965 and 1966 fish production per pond varied over a comparable range but with one added complication: The rank of each pond in the scale tended to change. Thus the pond that ranked eighth in 1964 ranked first in 1965 and third in 1966. In each successive year only one pond in the nine kept the same rank. The 1964 experiment indicated a random distribution of fish production. When the 1965 and 1966 results were added, they indicated a randomly changing randomness.

Thinking that differences in amounts and kinds of natural fish food organisms might be causing some of the unusual variation, in 1967 Dr. Buck and his colleagues Charles Thoits and Russell Rose fertilized all nine ponds heavily but uniformly. Their tabulation for this year shows a much greater fish production per acre but with the same high variation between best and poorest producing ponds and the same random change in the ranking of the different ponds.

In 1967 parallel studies using wading pools 10 feet in diameter stocked with the mouth-breeding tilapia fish gave exactly comparable results. The pools had a meticulously standardized layer of soil in the bottom and were filled with water from the same ponds. They were naturally colonized by aquatic organisms in the pond water and by aquatic insects having flying adult stages that could reach and oviposit in the ponds. The best pool produced 70 percent more fish growth than the poorest.

It is thus obvious that even in small and physically identical bodies of water there is great variation in fish production. Causes for this lack of uniformity could include differences in the timing or degree of colonization of individual ponds or pools, by different species of plants and animals having differing nutritional values as fish foods, by the effect that these organisms might have on physical conditions of the water, or other factors. At present we can guess at these causes, but we do not understand them and therefore cannot control them. Unraveling this tangled skein will be a difficult but most interesting undertaking.

Spreading Beauty

The American elm, with its lofty, gracefully arching branches, was for many years the favorite shade tree of eastern America, its high boughs making cathedralesque avenues of our streets and casting welcome shade around our homes. In the last 30 years the American elms of central and eastern America have been decimated by two diseases, the virus that causes phloem necrosis and the fungus that causes Dutch elm disease. Known control measures have

The American elm showing its typical growth form as a mature tree. (Photo by former Survey photographer W. E. Clark.)

been sufficiently expensive that only a few cities and towns have been able to give their elms adequate protection against these two deadly ills.

Illinois has been hard hit. In the southern third of the state a small proportion of the elms still persist in spite of phloem necrosis and Dutch elm disease and the absence of any control measures. In the rest of the state, except for extreme northern and western Illinois, less than 1 percent of the elms are still alive, both in towns and cities and in the stream bottoms along which the American elm grows in its native state. In the northern part of Illinois losses have already run as high as 90 percent in cities, such as Elgin and Aurora, which do not have sustained control programs.

In his latest tabulation of elm losses in northern municipalities using extensive and thorough control measures, Survey plant pathologist Dan Neely reports that in many of these towns the annual loss of elms is less than 1 or 2 percent. Such a small loss indicates satisfactory control under existing techniques. Out of 27 municipalities that have sustained control programs for the last 10 years, only 2 had 1967 losses above 4 percent.

Dr. Neely points out that efforts are continuing in many laboratories to find better control measures against phloem necrosis and Dutch elm disease and to discover genetic strains of the American elm resistant to their attack. If these efforts succeed, the American elm may once again be a familiar sight in our cities. At the moment, however, the outlook is far from promising.

Pheasants and Insecticides

In the several years since it became known that the chlorinated hydrocarbon insecticides in bird eggs could reach a concentration high enough to kill the embryo, biologists have watched with great interest the pheasant populations of east-central Illinois. In this intensively cultivated region corn occupies nearly half of the total land area and aldrin, one of the chlorinated hydrocarbons, is commonly broadcast and disced into the soil to control injurious insects attacking corn roots. Pheasant populations remain high, but the

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actual effect of aldrin on the birds could not be assessed.

Recent published studies based on known amounts of aldrin fed to penned pheasants have given the first reliable information concerning the effect on survival of pheasant eggs in relation to insecticide contents of the egg. When a pheasant takes in aldrin, it converts it to another chemical called dieldrin, and this compound is measured in the chemical analysis of egg contents. It was found that the critical level of dieldrin adversely affecting pheasant eggs lies between 8 and 14 parts per million. At the lower dosages, 3.2 and 6.4 ppm of dieldrin did not appear to affect either the fertility or hatchability of eggs.

Following this information, Survey wildlife specialist R. E. Greenberg collected 122 pheasant eggs from 21 clutches from the east central Illinois area and tested each for residues of dieldrin. All but one egg showed some dieldrin. The mean level of this compound was slightly less than 0.5 ppm while the maximum concentration found was 2.82 ppm. From these findings there is no evidence that aldrin and dieldrin are producing adverse effects on the fertility and hatchability of wild pheasant eggs in east central Illinois. There is still a possibility that these chlorinated hydrocarbons are inhibiting the production of eggs by wild hen pheasants but other tests will be required to investigate this facet.

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JULY 19[illegible], NO. [illegible]

Foam Fungi

When fungi are mentioned, one naturally thinks either of the parasitic species that attack other plants and produce disease symptoms such as sycamore anthracnose and various other blights, leaf spots, and cankers on various plants, or one thinks of mushrooms, toadstools, and puff balls which are the most conspicuous fruiting bodies produced by fungi. Fungi are tiny threadlike plants that have no chlorophyll, hence cannot manufacture their own food but must obtain it from living or dead tissues of other organisms.

It has been known for some time that a considerable fungus flora occurred in marine waters and a few forms have been described from fresh water habitats. Thinking that the latter might prove useful as ecological indicators of lakes and streams, Survey mycologist J. L. Crane recently began intensive studies on the fungi found in Illinois waters. His preliminary studies indicate that there is a surprising variety of aquatic fungi in Illinois. These fungi get their nutrients from decayed leaves, wood, and other organic matter in the water. The presence or abundance of some of the species appears to be correlated with the amount of oxygen in the water and these may prove to be valuable accessory indicators of either industrial or domestic pollution.

One feature of these fungi is proving to be of unusual interest. Dr. Crane has discovered that the natural surface foam of most lakes, rivers, and streams contains large numbers of the minute spores produced by the different species of aquatic fungi. Fungus spores are usually round or oval but in the aquatic species the spores are almost invariably S-shaped or tetraradiate, which Dr. Crane believes is an adaptation to aquatic life that increases the floating power of the spores. The foam samples bearing these peculiar spores can be brought into the lab, plated on media and the fungi identified much more rapidly than by trying to culture the fungi from submerged leaf or wood samples. Although the latter procedure is necessary in many instances, the foam samples give promise of furnishing a ready and rapid sample of the aquatic fungi occurring in various bodies of water.

International Fish Think

Survey aquatic biologist W. F. Childers has just returned from what could be a historic scientific meeting held in Russia.

In many tropical, heavily populated areas of Eurasia and Africa, fish provide the chief source of protein for the human

Multicellular spores of aquatic fungi showing sigmoid type on left (magnified 864 times) and tetraradiate type on right (magnified 300 times). (Photos by Dr. Crane.)

population. The production of fish has not kept pace with the increasing population and as a result many of these countries are faced with alarming protein deficiencies in their diet. Fish culture in these countries has been developed to a high degree, but no attention has been given to improving the kinds or strains of fishes. This problem has been recognized by the United Nations Food and Agriculture Organization and earlier this year the F.A.O. and the Russian government cooperated in organizing a seminar on genetic selection and hybridization of cultivated fishes.

Because of difficulties in using fish as experimental animals, remarkably little is known concerning their genetics, and any improvement in fish strains would have to be based fairly and squarely on such knowledge. At the survey Dr. Childers has been working for several years on hybridization and recombination of game fishes, amassing the best experimental evidence secured to date for obtaining an insight into at least elementary fish genetics. Realizing that this knowledge was of a fundamental type that would be basically applicable to any program of fish genetics, the F.A.O. invited Dr. Childers to serve as one of the lecturers on their seminar.

The seminar was attended by fisheries scientists from 14 countries including Dahomey, India, Madagascar, Nigeria, Philippines, Thailand, Uganda, and the United Arab Republic. As Dr. Childers points out, this seminar is just a start in the worldwide recognition of the possibilities of making enormous strides in fish production. Present day fishes are for the most part wild or little selected stock. If the flesh production of these fish can be increased in the same way that the razorback hog was bred into Berkshires, fish production could become a major food resource throughout the world.

Entomological Aid for A.I.D.

An important helping hand is being given to the agricultural universities of India through the cooperative efforts of the U.S. Agency for International Development (AID) and several midwestern universities. These AID projects make available to the Indian universities specialists in various fields of agricultural science, giving each visiting American new perspectives in his specialty and passing on to Indian scientists new theory and practice so badly needed to increase Indian food production.

Indian crops have their full share of insect pests, and this summer Survey entomologist L. J. Stannard is spending three months on loan to AID from the Survey to help out with a better understanding of India's insect problems. Dr. Stannard will divide his time between Uttar Pradesh Agricultural University at Pant Nagar and Jawaharlal Nehru Agricultural University at Jabalpur. His work in India will have four primary objectives:

- To begin research on the taxonomy of injurious insects and their relatives, including an insect identification program.
- To make a special survey of soybean pests, with special reference to injurious Indian viruses and insects which might be accidentally introduced into Illinois.
- To obtain comparative material of certain insect groups for which oriental material is needed for a better perspective on Illinois insect groups being studied by various Survey taxonomists.
- To arrange for continuing cooperation in these areas of research between entomologists in India and those of the midwestern United States.

Information on soybean pests may be especially useful. When soybeans were first grown in Illinois, they had practically no pests, but gradually one insect species after another started feeding on them. By now the Illinois soybean crop faces an increasing number of insect enemies, including grasshoppers, white grubs, rootworms, and thrips. The thrips, a tiny little insect only about one-sixteenth-inch long, is probably the vector of soybean virus, which also occurs in India. More information on the transmission of this disease would indeed be valuable. India has other agricultural pests that have the possibility of being accidentally introduced and becoming established and harmful in this country, and a prior knowledge of these by American

Truck equipped with direction-finding equipment used in tracking birds carrying tiny radio transmitters. (Photo by W. W. Cochran.)

entomologists might well prove the old adage, forewarned is forearmed.

New Tracking Dimension

In their past work attempting to radio track thrushes and other birds on their migratory flights, Survey wildlife specialists W. W. Cochran, R. R. Graber, and their colleagues have had unusual success in finding out the actual routes taken by the birds. Their longest sustained tracking was a thrush followed from Urbana, Illinois, to northern Michigan (*Illinois Natural History Reports,* No. 32). The birds were tracked by means of signals emitted by tiny radio transmitters attached to the birds, the signals being detected by delicate receiving equipment in a truck or airplane.

It was thought that this type of information would give clues as to how birds guided their movements during migratory flights, in other words, on the sensory basis of bird navigation and orientation. Because the migratory flights almost invariably take place at night, it is obvious that the birds must have some system of figuring out where to head when they take off on a migratory hop. That the system is accurate to a remarkable degree is evidenced by the fact that year after year migratory birds return to the same geographic area to nest.

If migrating on clear nights, birds could conceivably orient by celestial cues, but how they navigate under complete cloud cover — as they frequently do — has been a complete mystery. Presumably under cloudy conditions the birds require some directional cues gained before flight and which are held in memory until departure, enabling them to start in the correct direction. After getting on the wing they must maintain this correct direction by approximating straight line flight. Under these conditions, the birds would theoretically be subject to drifting errors caused by wind changes.

In trying to interpret their past flight records in terms of the possible effect of winds on direction of migration, wildlifer Cochran ran into various difficulties. The equipment in use could detect the direction of flight but not the elevation at which the bird was flying. A look at the weather records, however, showed that elevation was all important. Most bird flights occur between 3,000 and 8,000 feet, some of them as low as 1,000 feet and others reputedly at 10,000 feet or higher. At different elevations the winds may be remarkably different. Although occasionally wind velocity and compass direction may be nearly uniform for 5,000 or 6,000 feet, more often it is something like the mixture shown in the following table:

Elevation	*Wind Speed*	*Wind Direction*
Surface	5 mph	W
1,000 ft.	15 mph	NW
3,000 ft.	25 mph	NNW
5,000 ft.	15 mph	NW
8,000 ft.	5 mph	NE
10,000 ft.	25 mph	ENE

Occasionally wind changes are more extreme. On one night at 3,000 feet the

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wind was 35 mph and out of the southwest; at 5,000 feet it was 60 mph and out of the west. Obviously under these conditions it is imperative to know the flight elevation of a bird in order to be able to interpret the effect of wind on its course or its orientation.

In an effort to ascertain elevation, Cochran is trying various improvements in their tracking techniques. He has already designed new equipment that will give them both the elevation and the direction of a radio tagged bird, especially if the receiving station is on the ground, that is, mounted in the truck. This equipment is not yet small enough to put on thrush-size birds, but it has been used successfully in test trackings of Canada geese. Whether or not this equipment can be redesigned into a small enough package for use on small birds is at the moment doubtful.

A second approach, now being worked on intensively, is to work out a device that will couple an altimeter with the transmitter in such a way that the changes in altitude will send out distinctive code signals. Present day equipment to convert altimeter readings to changes in electrical current is much too bulky to use on birds, but the Survey team is working on some new wrinkles that may lick this problem. We still don't know how birds navigate, but it looks as though our ignorance gap is narrowing.

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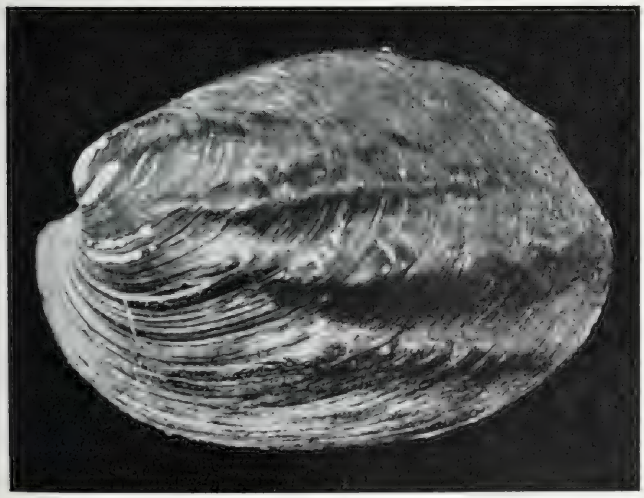
AUGUST 1968, NO. 70

Polluted Pearls

Harvesting of clams or mussels for pearls and pearl shell was once a thriving industry on the Illinois river. In 1909, at the height of the industry, over 2,600 clamming boats brought in thousands of tons of shells. Since 1917, pollution has restricted good clamming to the lower 80 miles of the river where a small clamming industry still persists. In recent years increasing demand by the Japanese for mussel shell to be used as seed for starting cultured pearls has revived interest in fresh water clamming.

Since mussels are relatively slow moving animals which live to be fifteen to twenty years old, studies of fluctuations in their populations make a very unique and useful method for evaluating the effects of pollution and siltation on aquatic life in the river. To compare the present mussel fauna in the Illinois river with records and collections taken many years ago, Survey aquatic biologist W. C. Starrett made a complete survey of the mussel fauna of the river in 1966. This survey was part of a cooperative project with the United States Bureau of Commercial Fisheries and the Illinois Department of Conservation and included studies on the biological and chemical effects of pollution and siltation.

After comparing the results of the 1966 survey with previous records of mussel fauna from the Illinois river, Dr. Starrett reports that drastic changes have been caused by domestic and industrial pollution since 1900. In the 1870-1900 period, there were 47 kinds of mussels in the river, according to records made at that time. Reports from the years 1906-1912, showed 43 kinds of mussels present. By 1966, only 23 kinds of mussels were collected. In other words, there has been a loss of 24 kinds of mussels between 1900 and 1966. In addition, five species of mussels taken



Shell of a three-ridge mussel, the most common mussel found in the Illinois river. (Photo by Dr. G. W. Bennett.)

in the 1966 survey were represented by only single specimens and four of these were taken in the lower river only one mile from the Mississippi.

The range of the mussels is now quite limited in the river. No living mussel was taken in the 1966 survey in the Starved Rock or Marseilles navigation pools. Most of the mussels were dead in this section of the river by 1912, following the opening of the Chicago Sanitary and Ship Canal in 1900. There are very few mussels living in the river from upper Peoria Lake to the Starved Rock dam. Although several good mussel beds exist in Peoria Lake, they contain very few species. The mussel fauna is quite scanty between Havana and the Peoria-Pekin area as a result of pollution.

As would be expected, the richest mussel fauna that persists today is found in the lower 80 miles of the Illinois river where pollutants from the upper portions of the river have been diluted by large volumes of drainage water. The absence of dams, large industrial centers, and areas of urban concentration from Beardstown to the Mississippi results in a continual reduction of siltation and pollution in the direction of river flow. It is in this lower 80 miles of river where nearly all of the commerical fishing for mussels is done today. The most common species found today is the three-ridge mussel, in contrast to the many species which were abundant around the turn of the century.

According to Dr. Starrett, the mussel study of 1966 reflects changes in the river not discernible by other methods such as chemical and bacteriological measurements. Hopefully, the data collected in this survey will be of considerable value in studying the effects of siltation and pollution and will aid in the search for ways to clean up our streams and rivers and prevent further pollution.

To Dam or Not to Dam

With the current arousal of public interest in pollution, there is rather general agreement that we must find ways to avoid further pollution and to clean up our contaminated streams and waterways. One area where there is sharp disagreement, however, concerns the relative benefits of damming streams to create artificial reservoirs.

Those in favor of dams point to the urgent need for more outdoor recreational areas. They cite municipal water supplies, flood control, low-flow augmentation during drought, and economic improvement of the local community as auxiliary benefits of the dam and reservoir.

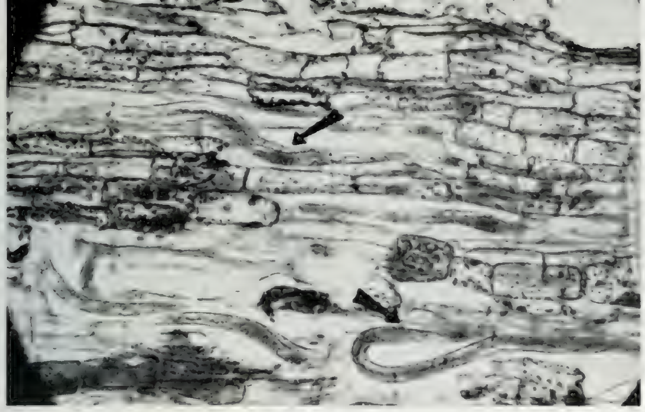
Conservationists, on the other hand, prefer a flowing stream with sandbars and gravel riffles alternating with clear pools, to a manmade lake with its picnic facilities, parking areas, and marina. They are also concerned about siltation and the destruction of natural habitats for characteristic native fish and wildlife.

The scientist working in these areas realizes the acute need for additional public areas for outdoor recreation and he is aware that a scenic gorge in a wild area is more apt to be feasible for dam construction than a meandering stream in flat, fertile, expensive farmland. He is also aware that the natural area harbors the habitats for wildlife that we value as a natural resource and a part of our heritage. His task is to investigate that facet of the problem within his sphere of competence and to report objectively his findings so that any group who wishes to do so may cite his findings as evidence.

Such a study, entitled "An assessment of changes in the fish fauna of two Illinois rivers and its bearing on their future," by Survey ichthyologist P. W. Smith, has recently been published. The report documents changes in fish populations and identifies the factors responsible. Evidence is presented that dams have probably contributed more than pollution to these demonstrable changes. Single copies of this paper are available to interested persons upon request to the Illinois Natural History Survey.

No Privacy

Insects and mites have their homes in varied places from the intestinal walls of horses to tiny niches under the bark of trees. Some of the most unusual homes are called plant galls which are constructed by



Enlarged photo of meadow nematodes in root cortex of Persian lilac. (Photo by Dr. Schoeneweiss.)

the insect or mite's host plant. Galls are abnormal vegetative formations produced by plants in response to invasion by insects, mites and a few other organisms. Generally the insect or mite gall maker causes little harm to its plant host even though the gall-home may be quite conspicuous, and may arouse the concern of the owner of the plant attacked.

Presently Dr. Appleby of the Survey's Economic Entomology Section is keeping records of the distribution of gall makers within the state as well as their host plant and conducting research on the life histories of several gall makers. To date he indicates that one of the most common galls is the maple bladder gall on silver maple caused by the feeding of tiny eriophyid mites. With continued studies we will have a better idea of who lives in these unusual homes, how long the renter stays, plus other information on his home life.

The Worm Turns

Tiny, almost microscopic roundworms called nematodes have been familiar to scientists for centuries. These animals occur in countless billions in nearly all the known soils of the world as well as in fresh and salt water. Although most nematodes are saprophytic and feed on dead organic matter, a number of species within the group known as Tylenchidae, which means stylet- or spear-bearing, are parasitic on living plant roots. The severe damage caused by the soybean cyst nematode, the golden nematode of potato, and the burrowing nematode associated with citrus decline, is well known. Whenever these pests are found, rigid quarantines to prevent their spread are put into effect.

Although considerable research has been conducted on those species with high destructive potential on food and fiber crops, little is known about the many nematode species which attack woody ornamental plants such as shade trees, shrubs, and evergreens. It has been demonstrated that dagger, spiral, pin, meadow, and root knot nematodes are parasitic on roots of woody plants but valid research data as to which of these species causes significant damage is sadly lacking. Nematologists generally agree that heavy attack by parasitic nematodes can result in retarded growth, yellowing of foliage, reduced winter hardiness, increased disease susceptibility, and a general weakening of affected plants. In addition, one species: the dagger nematode, has been shown to transmit at least two plant disease viruses from diseased to healthy plants. Scientific evidence that dagger nematodes may serve as vectors or carriers of plant viruses has prompted the Canadian department of agriculture to adopt a policy of refusing entry into Canada of any shipment of balled nursery stock from the United States unless the plants have been treated with an acceptable nematocide. In the United States, California, Florida, and New York have import restrictions on nematode infested nursery stock and other states are contemplating such legislation. Since Illinois growers ship nursery stock to interstate and international markets, restrictive import legislation is of much concern to the Illinois nursery industry.

To obtain much needed information on the significance of parasitic nematodes in the production and survival of nursery stock, Survey plant pathologist D. F. Schoeneweiss, in cooperation with nema-

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tologists from the University of Illinois and the United States Department of Agriculture, has initiated a comprehensive, long-range study of nematodes on woody plants in Illinois. Early studies reveal the presence of parasitic nematodes, particularly dagger, meadow, and spiral nematodes in all Illinois nursery soils sampled. Many other species have also been found in the state. Infestations of root knot nematodes are common on barberry in Illinois and extremely high populations of meadow nematode were found in roots of lilac. The effects of attack by these and other nematode species on woody ornamentals is being investigated.

Soil treatment with fumigant and nematocidal chemicals has given good control of parasitic nematodes in the south and southeast where soils are predominantly sandy and porous. In Illinois, however, soils are usually heavier and have a high clay content, which prevents the movement of chemicals through the soil. Much painstaking research may be needed before adequate control measures for nematode parasites of woody ornamentals in Illinois can be developed.

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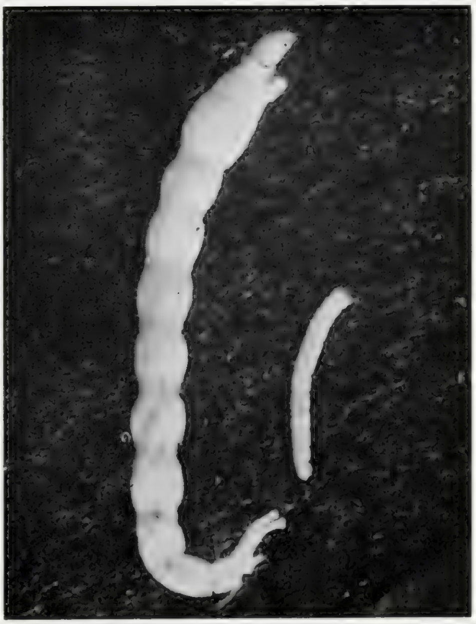
SEPTEMBER 1968, NO. 71

Landlocked Midges

The study of immature insects has over the years provided a valuable insight into the diversities and complexities within various insect groups. Such has been found during the present study of the Chironomidae or midges of Illinois, wherein the adult life span of a chironomid is only one to two weeks compared to some fifty weeks for the larval stage. Few people are likely to have seen a chironomid larva although they are among the most abundant of macroorganisms found on the bottom of lakes, ponds and streams.

They are distinguished by having a distinct chitinous head, an elongate segmented body with a pair of widely separated anterior and posterior prolegs with apical hooks, two or three pairs of anal gills (used for the uptake of oxygen from the water), and a pair of anal papillae with several coarse apical bristles. The immature chironomid has always been considered strictly aquatic in its habitat, but during the last year several exceptions to this rule have been found. From collections of moss taken in southern Illinois, W. Brigham of the Survey's aquatic biology section produced several distinctive specimens of midges which were terrestrial in their habits. He subsequently found specimens living in Hemlock cones and leaf litter, well away from any aquatic environment. The presence of these terrestrial forms has initiated an investigation by Survey entomologist D. W. Webb to determine the number of different species and the distribution of these forms in North America with the result that specimens have been collected from peat bogs in northern Illinois, corn fields in western Illinois, and, with scattered references to these terrestrial forms in the literature, in potato and tobacco seed beds.

These terrestrial forms show distinctive morphological differences from their aquatic relatives. Although they have a distinct chitinous head and elongate body, the posterior end of the body is rounded and lacks anal gills and anal papillae, with the posterior prolegs fused and often retracted into the body. The absence of the anal gills is apparently the result of their adaptation to a terrestrial environment



A terrestrial (left) and aquatic form (right) of chironomid larva. (Photo by Survey photographer Wilmer Zehr.)

where oxygen is absorbed through the entire body surface.

The occurrence of terrestrial forms within a highly successful group of aquatic organisms poses many questions to the scientific investigator. Why should some members of a successful aquatic group want to strike out into a world where they must compete with organisms that have successfully inhabited the land for hundreds of years? What physiological advantage is there in leaving an ideal habitat to venture into an area where desiccation poses a major fight for survival to an aquatic organism composed of 85 percent water? A thorough study of these forms may produce answers to these questions.

Physical Fitness in Rabbits

In studying the migrations of cottontail rabbits into study areas and in studying the month-to-month condition of rabbits, an easily computed index of the physical condition of each rabbit was needed. Wildlife researcher James A. Bailey has devised such an index from a formula derived from an analysis of the relationship between lengths and weights of rabbits.

A total of 499 rabbits from the Allerton Park 4-H area and the University of Illinois farms near Urbana were weighed and measured. Rabbits were measured to the nearest half a centimeter by stretching them full length and measuring from the tip of the nose to the tip of the fur on the hind legs. Each animal was weighed to the nearest ounce and the weight converted to grams. Rabbits were captured in wooden box traps in the Allerton Park 4-H area during a ten-day period near the beginning of each month from November through March in 1964-65 and 1965-66. All animals were tagged, weighed, and measured, and indices of physical condition were computed.

In 1964-65 the average indices of physical condition were significantly higher than the corresponding indices for 1965-66. In both years peak condition occurred in early January and declined between January and February. In November, 1964, and December, 1965, rabbits designated as immigrants (from nearby cultivated fields) had significantly lower average physical condition indices than did recaptured resident rabbits in the Allerton 4-H study area.

The condition index provides a useful tool for the wildlife researcher in evaluating differences among weights of rabbits, since it permits comparisons between different length and age classes of animals. We should learn much more concerning the growth and development of individual rabbits and rabbit populations in the future using this index.

Reciprocity

Over the years the Survey has adopted a policy of making its extensive scientific collections available to qualified specialists who were not members of our staff. This policy has resulted in the publication of faunal studies on selected groups for Illinois. Such Survey publications as the *Leafhoppers of Illinois,* the *Handbook of Illinois Mammals,* and the *Handbook of Illinois Snails* have been written by non-Survey specialists. Publications such as the *Mosquitoes of Illinois* and the *Aphids of Illinois* have been written by Survey taxonomists in conjunction with non-Survey specialists.

The Survey's collections have provided ecological, distributional, and morphological information for these faunal studies and many new species have been discovered in the course of these studies. The resulting publications have been recognized throughout the world for their comprehensive and thorough treatment of these groups.

In keeping with the Survey's long history of research on aquatic groups of animals, and in view of the state and national emphasis on water pollution, several groups of aquatic invertebrates are being studied by non-Survey specialists. Dr. W. D. Williams of the University of Waterloo, Waterloo, Canada, has studied the Survey's aquatic isopod collection in preparation for a revision of the genus *Ascellus* for North America. On returning the specimens Dr. Williams commented that because of the large number of species

Cottontail rabbit being measured for physical condition index. (Photo by Survey photographer Wilmer Zehr.)

represented in the Survey's collection he was able to unravel a number of synonymies in the genus. He designated a number of Survey specimens as types, and these are deposited in our collection.

Mr. Roy T. Sawyer, formerly a graduate student at the University of Michigan, is preparing a manuscript on the *Leeches of Illinois*. This report is based on the Survey's extensive leech collection, which Mr. Sawyer says is one of the most comprehensive state collections in North America. This publication will include information on the ecology, biology, distribution, and morphology of the thirty Illinois species as well as descriptions of several new species and a key to the native species.

Longer Pheasant Season

Because of rainy fall weather in 1967, the corn harvest in Illinois was nearly a month later than normal. By November 30 only 63 percent of the corn had been harvested. As a result of the corn standing in many fields, pheasant hunting was poor during the regular hunting season of November 18 to December 17 and the Department of Conservation extended the 1967 season two weeks to December 31.

Questionnaires requesting information on the number of hunter-days used and the number of cocks killed during the extended season were sent to hunters in Illinois. These were prepared and evaluated by wildlifers S. L. Etter and R. E. Greenberg. Data obtained from 195 hunters were tabulated indicating that 110, or 56 percent of these had hunted during the extended period and that 29 percent of the season's hunting of pheasants occurred during this two-week period.

The reported harvest of cock pheasants indicated that 28 percent of the cocks bagged during the entire 1967 season were taken during the extended period in December. Although the additional hunting pressure and kill resulting from extending the season for two weeks resulted in a higher proportionate harvest of cock pheasants than would otherwise have occurred, the observed sex ratios after hunting did not show this. After the 1967 season the

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observed sex ratio was 42 cocks per 100 hens, significantly higher than in 1965 and 1966 (32 cocks per 100 hens).

The study indicates that the season extension in 1967 was successful in providing additional hunting recreation, and that the increased opportunity to hunt was well received by a large majority of the sportsmen who responded. There was no evidence that the cock pheasants were more vulnerable to hunting pressure during this two-week period or that the additional hunting adversely affected the sex ratio of pheasant populations. These findings suggest that cock pheasants would not be overshot during seasons as long or longer than the extended hunting season of 1967 and that longer hunting seasons may be desirable in terms of recreation and optimum use of available resources.

No DDT

Those persons who have acquired the Illinois Natural History Survey Circular 53, *Dutch Elm Disease in Illinois,* or Circular 46, *Illinois Trees: Their Diseases,* should know that the fact that the recommendation of the use of DDT as a spray in controlling insects which spread these diseases has been discontinued. The official Survey statement now being added to these two Circulars reads as follows: "The Illinois Natural History Survey no longer recommends the use of DDT in Illinois for the control of Dutch elm disease and elm phloem necrosis. Because of its long residual effect, DDT can be hazardous to animal life. DDT is a possible contaminant of agricultural crops adjacent to treated areas and of streams flowing through or near treated areas."

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OCTOBER 1968 NO. 7[illegible]

Another Generation

The alfalfa weevil has usually been considered a one-generation pest. Typically the eggs hatch in early spring and the larvae develop during April, transforming in late April and May into the adult weevils. These adults mature during the summer, mate in the fall and spring and the females then lay eggs in late fall and early spring. These hatch in early spring and produce the very large and destructive April generation of larvae.

In the course of intensive studies on the life history of these weevils, Survey entomologist C. E. White noticed a second group of weevil larvae appearing in June and July. Seeking an explanation for this atypical phenomenon, he discovered that a small percentage of the females emerging in May from the first generation mature very rapidly sexually. But all the males apparently require the full summer period to become sexually mature. These weevils, however, have a long adult life compared with most insects, and males that emerge during the May of one year live until the following spring. Some of them remain active until May, when adults of the next year's spring generation emerge. These long-lived males mate with newly emerged females. The females then lay viable eggs, which produce larvae of a second generation. The second generation appears in June and July. Because, at the present time, only a few males survive long enough to mate with May-emerged females, the second generation is sparse and produces negligible damage to the alfalfa plant.

In assessing the control impact of the second generation, entomologist White points out that some of the present parasites of the alfalfa weevil depend to a large extent on second generation eggs

A 5-inch stand of April alfalfa near Lawrenceville "stopped in its tracks" by the alfalfa weevil. First the foliage turns almost white as in the central part of the picture, then the alfalfa plants literally disappear as the weevils complete their feeding. (Photo by Dr. E. J. Armbrust.)

and larvae for their development. At the present time there is a distinct possibility that this second generation is actually beneficial to the biological control program because it permits the build-up of parasites to higher levels than would be possible with a strictly single-generation weevil. There is always the danger, however, that the second generation of the weevil might become more abundant, abundant enough to produce economic losses to late cuttings of alfalfa. If this should happen we would need to initiate a different schedule of control measures to combat this highly destructive alfalfa pest.

More About Verticillium Wilt

The rising cost of planting ornamental and shade trees, and the even higher cost of replacing these shrubs and trees when they die, makes the fungus disease Verticillium wilt more important to homeowners and landscapers every year. This puzzling killer (see *INHS Reports* Number 61) is one of the most constant threats to a tremendously wide range of shrub and tree species grown in Illinois.

While striving for some means of control of the disease in plants that become infected with it, Survey plant pathologist E. B. Himelick has also been keeping an eye open for ways of prevention. In many instances, a species of plant may generally be susceptible to attack by a particular disease-producing fungus but certain varieties or clones of that plant species may be resistant to the fungus. With this in mind, Dr. Himelick has started a series of tests to try to find such resistant clones of tree and shrub species normally susceptible to attack by Verticillium wilt.

Because so little is known concerning the transmission of Verticillium wilt and because of lack of space in Survey plots to grow large numbers of sapling trees, a series of initial inoculations is being made with seedlings. Seed is procured from trees that show little or no damage in areas where other trees of the same species show disease symptoms. It will undoubtedly be some time before techniques will be developed for mounting a full-scale investigation of this problem.

In the meantime Dr. Himelick has been assembling a list of ornamental shrub and tree species that are susceptible to Verticillium wilt attack and those species for which susceptibility has not been demonstrated. Dr. Himelick points out that such a lack of demonstrated susceptibility does not mean that the species are resistant to the disease because every year a few more tree or shrub species are added to the list of those that suffer from the wilt. Even so, shrub and tree species for which susceptibility has never been demonstrated are still the best bet for replacing plants killed by the fungus. Dr. Himelick plans to summarize his information on the susceptibility of Illinois shrubs and trees to Verticillium wilt and make it available to Illinois users in a forthcoming Survey *Biological Notes,* planned for completion early next year.

Honoring Their Own

On September 22, in a solemn ceremony under a kindly sun, the people of Henry and neighboring counties unveiled a marker commemorating Benjamin Dann Walsh, Illinois' great pioneer entomologist. The marker, erected on the west side of State Route 82 a few miles south of Cambridge and about a mile south of the old Walsh farm, was presented by D. E. Sunmark, Division of Highways, and R. C. Birk, Illinois State Historical Society; unveiled by Miss Alice Beman, of Galva and Stacey Grammer, of Cambridge, descendants of Walsh's relatives; and accepted by Reuel T. Gustus, president of the Henry County Historical Society and Morris E. Nelson, a director of the Illinois Agricultural Association. Tribute was paid to Walsh by Paul C. Johnson of the *Prairie Farmer,* to which Walsh contributed entomological articles regularly, and H. H. Ross, of the Illinois Natural History Survey, of which Walsh was one of the earliest precursors and one of its "patron saints."

Born and well educated in England, Walsh and his wife settled in Henry County, Illinois, in 1838. He purchased a 300-acre farm which he operated until 1851, when he moved to Rock Island and

entered the lumber business. He had collected insects in England and, in his new setting of the American Midwest, became fascinated with the strange insect fauna. He wrote many excellent scientific contributions on these interesting creatures occurring in Illinois.

His scientific study of insects was only one of Walsh's concerns with these little six-legged animals. As eloquently pointed out at the commemorative ceremony by Morris Nelson, Walsh felt a great responsibility to help his fellow man and devoted great efforts to figuring out ways to control the many insects that made farming in the area a hazardous occupation. In 1867 the Illinois State Legislature appointed Walsh the first Illinois state entomologist, a position he held until his untimely death as the result of a railroad accident in 1869. As pointed out by Paul Johnson, principal speaker at the marker dedication, Walsh was given no work fund or assistance and had to do all his entomological work in his home. Yet in spite of these handicaps, he made a remarkable beginning toward an understanding of how to control insect pests in the Midwest.

Benjamin Dann Walsh, 1808-1869, Illinois' first State Entomologist. (Photo from the files of the Illinois Natural History Survey.)

It was plain from the thoughts expressed at the ceremony that the people of northwestern Illinois had taken Walsh to their hearts as one of Henry County's early sons who had labored long and hard for the good of his neighbors. But they realized also that his work had extended far beyond the local scene, that the scientific devotion and ideals of Benjamin Dann Walsh, the first economic entomologist in the Midwest, form a priceless part of the historical heritage of Illinois.

Algal Ups-and-downs

The primary source of food for all the animals that eventually live in a lake is microscopic plants or algae living in the water. These tiny organisms use sunlight as an energy source and manufacture carbohydrates and other nutrients from carbon dioxide and other substances dissolved in the water.

In Illinois lakes the richest concentration of floating or plankton algae usually occurs in the upper layers of the water. While observing conditions in Lake Glendale near Robbs, Illinois, Survey aquatic biologist D. F. Hansen noticed an obvious visual scarcity of plankton algae in the surface waters. To find out the situation, he made a series of plankton net tows at 3-foot intervals between the surface and bottom. In these samples the algae were scarce at all depths except that of 18 feet. At this depth the fine-meshed silk net used for the plankton tows usually came up with a bright green coating of algae, which was later identified from the bottled sample as blue-green algae belonging to the genus *Oscillatoria*.

In this connection, many studies have been made of the occurrence of the free swimming minute animals constituting the zooplankton of lakes, and it has been observed repeatedly that there is a marked movement of these organisms up to the surface at night (presumably to feed on the plankton algae in the upper waters) and back to lower depths during the day. Little work has been done, however, on the algal portion of the plankton. In order to find out if the *Oscillatoria* in Lake Glendale were behaving in the same

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fashion as the traditional behavior pattern of the animal plankton, Dr. Hansen made a series of night plankton catches at the same 3-foot levels as those made during the day. The preliminary results are quite surprising. The *Oscillatoria* had indeed moved up but only about 3 feet and the night concentration was at 15 feet rather than at the 18-foot level at which they were found in the daytime. Furthermore, these algae were hundreds of times more abundant at the 15-foot level at night than at their 18-foot level during the day. Where the tremendous abundance of algae goes during the daytime is somewhat of a mystery. It may be that during the day they settle on the bottom, in which case the plankton sampler would not collect them. Whatever the daytime location of these little organisms, it is plain that much more intensive work will need to be done to establish where and when within the lake the primary food supply is produced. Dr. Hansen is now planning additional series of experiments to test various possibilities during the next growing season.

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NOVEMBER 1968, NO. 73

Pretty Poinsettias

Did you ever buy a beautiful Poinsettia plant, put it proudly in the middle of the dining room table, and in a few days have all its leaves drop off? If so your Poinsettia plant was undoubtedly suffering from root rot. Although remarkedly immune to insect and mite problems, Poinsettias are susceptible to several root rots which give growers constant headaches in producing the million and a half plants sold every year in Illinois.

Until recently Poinsettia root rot was thought to be caused by three kinds of fungi, two of which attacked cuttings and young plants either while they are in propagation benches or soon after they are put in pots. The third fungus hits the plants just as they reach marketable condition and causes root rot, stem rot at the soil level, and subsequent rapid defoliation. Chemical controls are known for the two species damaging the cuttings and small plants, but none is known for the root rot that attacks the newly-mature plants. To date, the only means of holding this latter root rot in check has been sanitation, that is, sterilizing soil and equipment. If sanitation breaks down even momentarily, disaster can strike.

Poinsettia plants. *Right*, healthy plant having all its stem leaves; *left*, mature plant with root rot, after all but the very top leaves have dropped. (Photo by Survey photographer Wilmer Zehr.)

Two years ago Survey plant pathologist R. S. Perry began efforts to find a chemical control for this later disease: he did not succeed. In culturing diseased Poinsettia roots, however, he discovered that in some instances he recovered only the organism considered to be the root rot causal agent. In other instances he recovered only another kind of fungus long considered to be an innocuous soil contaminant. Puzzled by the regularity of these dual results, plant pathologist Perry innoculated healthy Poinsettias with this fourth, supposedly "innocent bystander" and discovered that it produced the same disease symptoms as the supposedly sole pathogenic fungus. Knowing now that not one but two kinds of fungi produce this late Poinsettia root rot opens up clearer avenues to finding a control agent.

Drawdown Roulette

As a method of improving bluegill fishing, Survey aquatic biologist G. W. Bennett and his co-workers H. W. Adkins and W. F. Childers experimented with fall drawdowns of the water level at Ridge Lake coupled with supplemental feeding programs. The drawdowns reduced the blue-

gill population to relatively small numbers with the idea that these small numbers would grow rapidly when the lake was filled the next spring. The full lake has a surface area of 16 acres. If this level is reduced 10 feet, the area is reduced to about 11 acres. If the level is held there over winter, the bluegill population decreases from 50,000 or more to 19,000 or 20,000 fish. If the lake level is dropped 15 feet, the area is reduced to about 5 acres, and the bluegill population shrinks to 8,000 or 9,000.

Drawdowns to the 15-foot level in 1964 and 1965 set the stage for unusually good bluegill fishing in 1965 and 1966. A drawdown of only 10 feet in 1966 also produced excellent fishing in 1967, and it appeared initially that this lower drawdown, with the subsequent greater survival of bluegills (20,000 instead of 9,000) might be a figure representing close to maximal fishing.

In the fall of 1967 the water was lowered again by only a 10-foot drawdown. In 1968 the bluegills showed a large increase of small fish in relation to large fish. This suggests that a 15-foot drawdown, in short, extreme reduction of bluegill populations, is necessary to maintain good bluegill fishing. To test this idea, the lake will again be lowered by 15 feet this fall and bluegill populations observed next summer.

More About Apples

Another year's results have now been tabulated in the investigations to discover if mite resistance could be coupled with scab resistance in new varieties of apples being developed by an interstate team of horticulturists from the University of Illinois, Southern Illinois University, Purdue University, and Rutgers University (*INHS Reports*, No. 62). Dr. D. F. Dayton of the University of Illinois Department of Horticulture and Survey entomologist R. H. Meyer have been working together on the Urbana portion of this problem.

In his preliminary experiments made in 1967, Dr. Meyer found that at least some of the new apple hybrids appeared to be resistant to mites. In 1967 he ran an extensive series of tests on 80 seedlings of each of three crosses that were also being tested for scab resistance, and these exhibited varying populations of mites when all were artificially infested with similar initial populations. In 1968 Dr. Meyer removed the seedlings with the highest populations, then again removed the samples with the highest populations, leaving only about 10 percent of the seedlings that had the lowest populations. After this second removal, mites on the remaining seedlings disappeared rapidly, indicating that they had strong resistance to mite infestation.

From a tabulation of the amount of infestation that became established on the various hybrid individuals it appears that this resistance is a heritable character probably controlled by several genetic factors. At the present time there is some possibility that mite resistance and scab resistance might be linked in the genetic system to at least some extent.

A marketable scab-free, mite-free apple variety is still, however, far from a practical reality. An apple breeding program is a long range one requiring several years per experimental generation, and much crossing, testing, and evaluating will undoubtedly be needed before particular desirable characteristics can be combined in one individual apple tree that could be used for commercial scion stock. Until then Illinois apple growers will have to keep a sharp eye out for mites and use the best available methods to control them.

Nightlighting

When studying the behavior of game animals, it is necessary to make observations on wild individuals because animals living in and adjusted to the wild condition behave quite differently from tame ones. Before these wild animals can be identified individually, it is necessary to catch each specimen somehow and give it some identifying sign such as a numbered back tag or a dab of coloring, and then release it for further observation. It has proven quite difficult to capture these wild individuals in sufficient numbers for popu-

Nightlighting in operation. Truck equipment includes the high battery of floodlights and the spotlight operated by the driver; the catcher is using the standard net. This bird got away. (Photo by Survey photographer Wilmer Zehr.)

lation studies and to keep from injuring the animals. Injury might cause them to react abnormally.

Over the years many methods have been devised for trapping wild animals to be used in population studies, but most of these have not proven successful for securing adequate specimens of the upland game birds of the Midwest, especially pheasants, prairie chickens, and bobwhites.

The most promising technique for the capture of these birds has been nightlighting, and for the last 12 years Survey wildlife specialist R. F. Labisky has been using this technique to secure specimens for investigating the life history and habitats of these species in Illinois. The idea of nightlighting is very simple: A bright light is shone at the target individual, blinding it temporarily; the individual is approached rapidly while thus mesmerized and captured with a net. During the years of using this method, Dr. Labisky has experimented with different types of equipment, different types of approach, and other variables, and has recorded the weather conditions during nightlighting efforts. He has found that a combination of a series of several bright floodlamps mounted several feet above the top of the truck and a single bright hand-operated spotlight is an effective lighting arrangement. The high lights above the truck provide illumination for spotting quarry animals at night; the spotlight provides an intense beam for blinding the quarry during the attempted capture. A 12-volt car battery provides sufficient current for the spotlight. But an auxiliary gasoline a.c. generator is used for the high floodlights. Final capture of the bird was made with a cord-meshed net 30 inches in diameter, with a 10-foot handle.

Typical nightlighting using this equipment included driving the truck into fields suspected of harboring roosting birds, spotting the birds with the high floodlights, turning on the spotlight (simultaneously switching off the floodlights) and blinding the bird with it, maneuvering the truck close to the target bird, and making a rapid dash with the net and slipping it over the bird. The driver of the vehicle manipulated the lights; the netter rode on the fender of the vehicle in order to be ready to jump off and net the quarry.

During these efforts, Dr. Labisky found that the problems encountered were quite different between the various species. The crews had a much greater efficiency of capture with pheasants than with either bobwhites or prairie chickens. This was partly due to the fact that pheasants are found more often in cultivated fields, over which it is easier to drive and maneuver the vehicle. In autumn, prior to the hunting season, the crews caught nearly half of all the pheasants initially observed during nightlighting operations. In winter, after the hunting season, the birds became more wary, but even then the catch figures included a third of those located.

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Prairie chickens were the most difficult to capture because of their unusual wariness and because the young birds gain their wariness much earlier in life than do young pheasants. To catch prairie chickens, the crew had to increase the tempo of the entire operation after a target bird was observed.

Catching bobwhites proved to be tricky. Birds roosting in open fields were captured readily, but in many areas the birds roosted in terrain that was difficult to navigate at night. As a result it took longer per bird to catch the bobwhites although the efficiency of capturing them after they were spotted was as high as for pheasants.

Some time was spent capturing cottontail rabbits, but getting these proved to be a difficult task. At night cottontails seldom ventured more than 50 yards away from some sort of escape cover, and when disturbed they literally streaked to their sanctuary. This required bursts of speed up to 35 miles per hour on the part of the vehicle and extremely fast movement by the net operator.

Details of equipment developed for nightlighting these animals, capture success under various weather conditions, and much other useful information about these animals is contained in Dr. Labisky's recent Survey publication *Nightlighting, Biological Notes No. 62,* which is now available upon request from the Natural History Survey.

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DECEMBER 1968, NO. 74

Hybrid Bass

It was only natural that early efforts to produce faster growing, larger pan fish centered around attempts to hybridize the various species of sunfish that occur in the Midwest. The sunfishes themselves provided the initial suggestion because naturally occurring hybrid individuals were encountered frequently. These hybridization programs met with more negative than positive results, but they did demonstrate the possibilities of artificially improving fishing in small ponds and lakes through a controlled program of fish hybridization.

In 1967 Survey aquatic biologist W. F. Childers decided to investigate the possibilities of hybridizing largemouth and smallmouth bass. In Illinois hybrids between these two species have never been found occurring naturally, indicating either that the hybrids are inviable or that the two kinds of fish exhibit behavior patterns such that they do not hybridize in their natural environment. Dr. Childers mixed smallmouth bass sperm with largemouth bass eggs in the laboratory and discovered that the eggs were fertilized and that hatching and development of the hybrids were normal. When the fry became free-swimming, he released them in a farm pond containing no other fishes.

In central Illinois neither of the parent fishes reproduce until they are two years old. To everyone's surprise, the hybrids produced a large population of second-generation hybrids when they were only a

Hybrid specimen from a cross between the smallmouth and largemouth bass. This hybrid is intermediate between the two parents in color characters and diagnostic features of the head and fins. (Photo by Survey photographer Wilmer Zehr.)

year old. At the end of this first year the hybrids were approximately 8 inches long, somewhat larger than the expected growth of either parent. The first-generation hybrids (F_1) were essentially intermediates between the two parental types in color markings and diagnostic characters of jaws and fins. The horizontal black line of the largemouth was reduced to dark splotches near the tail and the dark stripes radiating back from the eye, characteristic of the smallmouth, were considerably reduced.

To compare the growth rates of the hybrids under competitive conditions, Dr. Childers stocked a 2.6-acre farm pond with 12 F_1 hybrids, 12 largemouths, and 12 smallmouths, each 8 inches long. Of these 36 fish, 34 were removed when the pond was drained 2½ months later. During this period the average increase in weight was 0.48 of a pound for the largemouths, 0.55 for the smallmouths, and 0.71 for the hybrids. The greater growth potential of these hybrids could well mean that the fishermen of Illinois will have a hybrid bass in their future.

Fungicide Testing

Fungicides lead a rough life. Many of them are applied to leaves and stems in dust or spray form. If applied as a spray, the liquid carrier in the spray soon evaporates and the fungicide forms a thin film on the plant surface we hope to protect. The sun and rain beat down on this chemical film, the wind whips at it, gases in the atmosphere try to dissolve it, and chemicals produced by the plant may seek to destroy it. Yet through all this we hope that this fungicidal layer will maintain its desired chemical qualities to the extent that a fungus spore drifting onto the protected surface will not be able to grow and penetrate the tissues of the plant.

Few good fungicides can take this beating for more than a couple of weeks, which means that fruit growers and others must apply a succession of sprays throughout the growing season. In the meantime the search for better and more persistent fungicides continues. The first step in the testing is usually to expose disease organisms in culture to minute amounts of the test compound. If satisfactory control is obtained, the chemical compound is then tried out in field plots to see how it will work when exposed to the elements.

In attempting to find satisfactory fungicides to control diseases of perennial ornamental plants, Survey plant pathologist Dan Neely and his colleagues have encountered numerous diseases for which no effective fungicide is known. Testing the great mass of potential fungicidal chemicals for each of these diseases posed serious problems of time and equipment. To short-cut the initial testing procedures, Dr. Neely is devising new techniques that combine culture tests with an artificial exposure of the fungicide to simulated weather conditions.

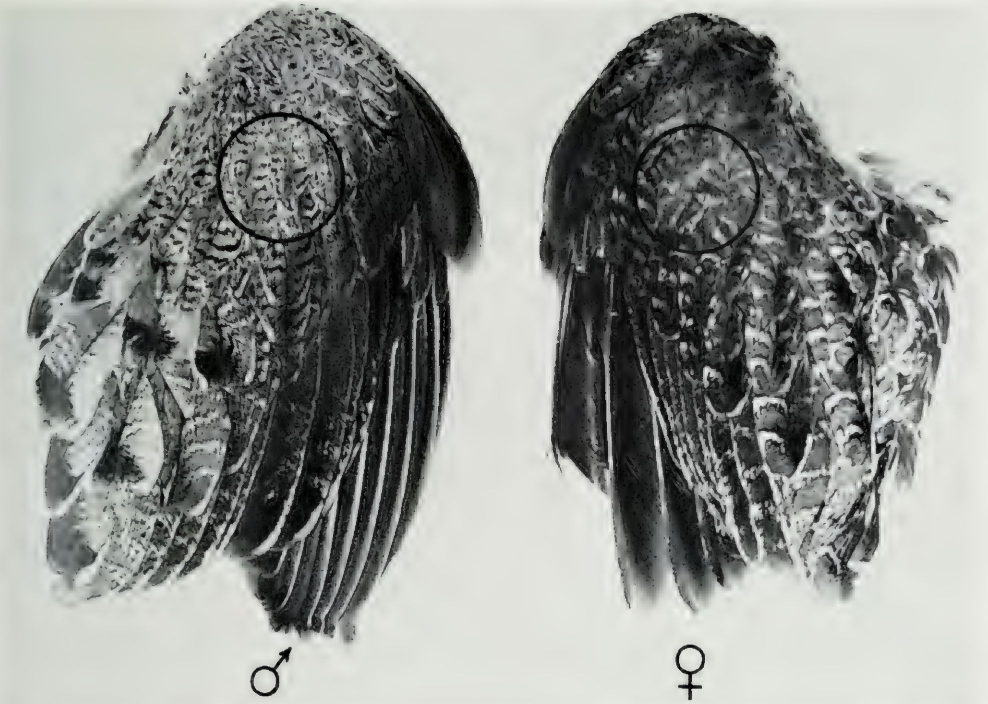
As a beginning, he devised a rain machine that will produce controlled rainfall patterns of desired amounts and intensity. Fungicides to be tested are applied uniformly to leaf surfaces of growing plants, the fungicide is allowed to dry, and then it is subjected to the desired rainfall pattern. Uniform discs of leaf are taken at regular intervals, and the fungicide remaining on the leaf sample is tested for its efficiency.

This addition of rain testing combined with initial fungicidal testing is proving extremely useful and a great time saver. Dr. Neely points out that the reason that the combination is so effective is that persistence of a fungicide on the foliage is just as important as its initial ability to kill fungi from the standpoint of practical control. He is now planning to add controlled light intensity and controlled temperature to the testing procedures in hope of further improving the speed and efficiency of intitial fungicide testing.

It Takes Practice

For many years wildlife investigators have solicited wings of quail from hunters and area managers in order to estimate proportion of juvenile to adult birds occurring in various areas. The age classes are readily recognized by color markings on the wings.

Another factor important in understanding population structure is a knowledge of the proportion of males and females. On this point the wings have not been helpful



Wings of the bobwhite, male to the left, female to the right. The diagnostic pattern on the middle wing coverts is in the black circles. (Photo by Survey photographer Wilmer Zehr.)

because no wing characters were known that identify the sexes reliably. If the sex of the bird from which the wing was clipped was not on the identification tag (and very often it was not), the sex of the specimen could not be determined.

Recently Survey wildlife specialist K. P. Thomas has discovered what appear to be differences in coloration between wings of the two sexes if the birds are 8 weeks or more old. In the males, the central portion of the middle wing coverts have fine, black, sharply pointed undulations that contrast with the surrounding portions of the middle wing coverts. In females the feathers of the middle wing coverts have wider, dull gray bands which contrast very little with the surrounding feathers. The diagnostic area is shown by a black circle on the accompanying illustrations.

These characteristics were somewhat obscure in 15 percent of the wings examined, due to variation in background color of feathers, missing or damaged feathers, and distortion of dried wings.

To test the reliability and usability of these wing criteria for sexing quail, wildlifer Thomas asked four other wildlife specialists of the Survey staff to sex his sample of over 100 juvenile and adult bobwhites. These four achieved an accuracy from 85 to over 90 percent. They found, however, that after a little experience their accuracy improved materially. After becoming thoroughly familiar with these characters it appears that most workers should develop an accuracy approaching 100 percent. This discovery will add a much needed dimension to quail research.

Insecticides for 1969

Entomologists of the Natural History Survey and the U. of I. College of Agriculture have again pooled their knowledge of the state's insect problems and prepared their annual suggestions for the use of insecticides to control pests affecting field crops, livestock, livestock buildings, vegetable crops, and infesting the home and garden. Aided by Survey entomologists

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H. B. Petty, Steve Moore, Roscoe Randell, and Don Kuhlman, these suggestions will be available by January 1 and may be obtained either from the Survey or the U. of I. College of Agriculture Information Office, or locally at the U. of I. County Extension Adviser's office.

The greatest changes from 1968 concern the control of western and northern corn rootworms and insects attacking corn seed. The latter include seed-corn beetles and seed-corn maggots. Changes in recommendations are due to the appearance in all these species of resistance to aldrin and heptachlor, insecticides commonly used to control soil insects. The application of the substitute insecticides will need to be synchronized carefully with the planting program. A special point made in 1968 and again stressed in 1969 concerns the extreme caution that needs to be exercised in soybean farming. Because Illinois soybeans enter the international market and may be shipped to countries having extremely rigid tolerance concerning the presence of chlorinated hydrocarbon insecticide residues in the beans, not only must these insecticides not be applied on the current soybean crop but the beans must be grown on soil that is virtually free of these insecticides that might have been applied in previous years. The need for this caution is very simple. The soybean plant has a high oil content and chlorinated hydrocarbons are transported to and stored in the oil in the soybean seed. These and many other items will be explained at the twenty-first Custom Spray Operators Training School on January 22-23, 1969, to be held in the Illini Room of the U. of I. Illini Union Building. Sponsored jointly by the Natural History Survey and the U. of I. College of Agriculture, this School is an annual workshop concerning the application of control measures for the suppression of insects, weeds, and plant diseases. Experts on various topics from the Survey and the University staff will talk about their respective specialties. A feature speaker will be Dr. C. R. Harris of the Canadian Entomology Research Institute, an international expert on soil insects.

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Wired for Eating

The increased abundance of the corn leaf aphid on Illinois corn plus the knowledge that it transmits at least one potentially destructive corn virus has made this little insect the subject of intensive study. Part of this activity has been an effort to find resistant strains of corn that the aphid would not attack. Testing for resistance, however, turned out to be a difficult business. First, it was discovered that different parts of a corn plant have a greater or lesser susceptibility to aphid attack at different ages, and there is a possibility that shaded and unshaded leaves, or plants growing in wetter or drier situations might also show different susceptibilities. Under these circumstances reliable testing calls for a large number of trials of aphids on different parts of different strains of plants.

The second difficulty concerned testing procedures. The older methods of observing the establishment and build-up of aphid colonies were time-consuming in the extreme. What was needed was a fast test of the acceptance or rejection of a given area of corn leaf as food by a single aphid.

Survey entomologists W. L. Howe and Roscoe Randell are now working with a micro-electrical gadget that seems to give the desired test. First, a fine flexible wire of pure gold 15 microns thick (smaller than a human hair) is attached by a conducting glue to the back of an aphid. The aphid is then placed on a section of corn leaf. This is connected to one pole of an electric circuit, the gold wire from the aphid's back is connected to the other. This wire apparently does not bother the aphid, which wanders over the corn leaf and seems to go about the process of getting a meal in typical fashion.

When an aphid feeds, it probes into the plant tissues with its extremely fine beak and injects small amounts of saliva. If it hits a desirable spot it settles down, continues to salivate, and sucks up the mixture of saliva and digested plant juices. The saliva is injected down one channel in its beak, the food mixture is sucked up through another channel. If a wired aphid

Corn leaf aphid with gold wire attached. The wire is the long thread leading out of the top of the picture. The light blotch on the top of the aphid is the dab of silver cement used to glue the end of the gold thread to the insect and produce a connection between the thread and the aphid that will conduct electricity. The aphid is about 1/16 inch long. (Photo by Survey photographer Wilmer Zehr.)

starts feeding on a charged leaf, the extrusion of saliva and ingestion of the liquid food sets up a conductive pathway, and the differential flow of electric current indicates the extent of these activities. The current can be recorded and measured on a revolving drum. With this technique Howe and Randell can determine in a few minutes if an aphid is wandering, probing, and rejecting the leaf, or sitting down, getting settled, and feeding happily.

Dr. Howe points out that this is a revolutionary technical breakthrough that will eventually have a tremendous potential for testing the feeding behavior of many insects for which we are seeking food plants resistant to their attack.

Still Here

Most Illinois lakes contain fish species that are characteristic of quiet pools and backwaters of rivers and creeks. These fish find their way into lakes naturally or are introduced by sportsmen. In a few areas of the state, notably in Lake and McHenry counties, there are some natural glacial lakes having truly lacustrine or lake-inhabiting species.

One of these is the pugnose shiner *Notropis anogenus*. One of the smallest of our native species, the pugnose shiner can be recognized by its sharply upturned mouth and the jet black stripe that extends from the tail fin to the snout and tip of the lower jaw. It almost invariably occurs in heavily vegetated, natural lakes.

First discovered in 1880 in McHenry County, Illinois, the species was formally described by the Survey's first chief, Dr. S. A. Forbes. Although subsequently found in two other Illinois lakes and in glacial lakes of other northern states from western New York to southeastern North Dakota, it is regarded as one of the rarest of North American minnows.

Until recently the species was believed to have been extirpated in Illinois, the last known Illinois specimen having been secured in 1909. It is believed to have disappeared also from certain other parts of its range.

In identifying the quarter million specimens of Illinois fishes assembled by chief fishery biologist A. C. Lopinot, of the Department of Conservation, and ichthyologist P. W. Smith, of the Survey, in cooperative collections begun in 1962, Dr. Smith ran across a delightful surprise. A collection taken in Channel Lake in June 1965 contained three specimens of the pugnose shiner; a collection made in a weedy part of Loon Lake in 1968 contained three more. The most recent batch of collections contained a seventh specimen from Grass Lake. Seven specimens among 250,000 does not indicate a huge population, but the pugnose shiner is still here.

Aster Yellows Again

In their studies of gladiolus diseases, Survey plant pathologists J. L. Forsberg and Walter Hartstirn were puzzled by the erratic behavior of aster yellows. This gladiolus disease would show up in one place or in one gladiolus variety one year and not the next. Although always present, there was no apparent pattern to where it would show up and the infestations of one year seemed to have no obvious relation to those of the preceding years.

Aster yellows is a peculiar disease that attacks a large number of plants including asters, petunias, zinnias, and gladioli. The causal agent is a virus or virus-like organism that is carried from plant to plant by leafhoppers, which feed by sticking their beaks into plant tissues and extracting their juices. Typically this virus interferes with the development of the flowers. These do not have the normal color of their variety but instead are green or greenish white and the petals look more like stunted leaves than normal flower parts. In infected gladiolus plants the spike may be twisted. The buds may be stunted green stubs that don't open. If they do open the petals will be dwarfed and misshapen and the telltale green in color. Gardeners who have an occasional petunia or zinnia infected with aster yellows often think that they have a new sport or mutant. The disease affects asters so severely that they are not grown commercially in Illinois although the climate is otherwise ideal.

In the course of their gladiolus field studies, Dr. Forsberg and Dr. Hartstirn

The pugnose shiner. This is a photograph of the painting in the historic *Fishes of Illinois* written by Forbes and Richardson, published by the Survey in 1909.

tagged glads with aster yellows symptoms, then dug them up in the fall when the plants had matured. Not only did the petals not develop on these plants, but the bulbs often failed to produce bulblets. During winter storage most of the bulbs died, and those that survived the winter failed to come up when planted the following spring. It is thus evident that, in gladioli, aster yellows is self-eliminating, extremely unusual in virus diseases.

In checking into the recent literature on these organisms, the plant pathologists discovered that in aster yellows and possibly some other diseases considered to be caused by viruses, the causal agents are not really viruses but very peculiar organisms called mycoplasma. These are peculiar saclike structures, the smallest a little smaller than the largest virus and the largest a little larger than the smallest bacteria. In terms of size, they bridge the gap between viruses and bacteria with a little overlap at each end. The closest known organism to the mycoplasm-producing aster yellows is one producing certain types of pleuropneumonia in animals. So new is our knowledge of these peculiar things that their implications for plant disease study are virtually unknown.

Up from the South

Most small birds migrate at night so that much of their passage goes unnoticed. Observing the passage of birds across the face of the moon, radar surveillance, and radiotelemetry are three methods that have been used to study nocturnal migration.

A few years ago Survey wildlife specialist F. C. Bellrose added a fourth dimension to these techniques: a small aircraft was equipped with additional landing lights, and nocturnal migrants were counted in the lighted path of the aircraft.

During the spring of 1968, wildlifer Bellrose made a preliminary investigation into the distribution of nocturnal migrants in eastern United States. A transect was flown from Pekin, Illinois, to Daytona Beach, Florida, and from there immediately north of the Gulf Coast to San Antonio, Texas. From Houston, Texas, a transect was flown back to Pekin, Illinois, thereby completing a huge triangular course.

The number of birds observed per minute varied little between Pekin and Chattanooga, Tennessee: an average of 5.5. From Chattanooga to Atlanta, Georgia, we observed almost two birds per minute, but from there to Daytona Beach, there was only one bird per minute. A noticeable lack of birds prevailed along the ridges of the Appalachian Mountains.

The largest number of nocturnal migrants were seen across the Florida Peninsula, where 19 per minute were recorded. In the Panhandle region of Florida only 8 birds were observed per minute. There were few migrants between Mobile, Alabama, and New Orleans, Louisiana — an average of 0.45.

From New Orleans to Lafayette, Louisiana, the crew observed six birds per minute, but from there west to Lake Charles, Louisiana, only 0.31 birds per minute. Between Lake Charles, Louisiana, and Houston, Texas, slightly over one migrant oc-

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curred per minute, but from there west to San Antonio, the number of migrants increased to over six per minute.

North through eastern Texas, small migrants averaged 6.4 per minute, but dropped off through Arkansas to about half that number. North through eastern Missouri and western Illinois there were only two migrants per minute.

Only limited conclusions can be drawn from one survey of nocturnal migration in this region. Nevertheless, it is apparent that small birds migrate on a broad front, with only the density varying regionally. It is also obvious that some small birds cross the Gulf of Mexico throughout its breadth. However, the greatest number of migrants seem to use the land bridges around the gulf. The large number of migrants moving up the Florida Peninsula, and the increased abundance of migrants between Houston and San Antonio, Texas, point up this probability. A mid-point in crossing the Gulf of Mexico appears to occur in the New Orleans–Lafayette, Louisiana, area and may represent migrants from the Yucatan Peninsula, the nearest point of land to the south.

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Marshaling Our Allies

The idea of using insect parasites and predators of other insects has long held out a tantalizing prospect for controlling insect pests. There are literally thousands of these insect parasites and predators, and many hundreds have been reared and released in attempts to control a wide variety of pest species. Here and there a real success story has emerged, as was the case of the vedalia beetle in the control of citrus scale insects in California. Occasionally parasites depress the population of noxious species at irregular intervals but do not prevent periodic and serious outbreaks. In the great majority of instances, little or no success has been achieved.

Up to the present natural species of parasites have been used in these attempts. With increasing information about insect genetics and more sophisticated equipment for rearing insects under a variety of conditions, there is a possibility that new, artificially produced genetic strains or even hybrid species would be more successful in controlling specific insect pests under specific climatic conditions than any of the natural species. Although improved parasites using special genetic strains has been achieved with certain orchard pests in Canada, this type of approach must still be considered practically in the realm of a dream. It is, however, a dream with sufficient potential that it will eventually be pursued vigorously.

The first step in such an undertaking is to find out what parasitic or predaceous species are available and the first place to do this is at home. Survey entomologist W. E. LaBerge estimates that well over 3,000 of the 20,000 species of insects probably occurring in Illinois are parasites or predators of other insects. This figure includes at least a thousand species of beetles, 400 species of flies, and nearly 2,000 species of parasitic wasps. The most im-

A parasitic wasp belonging to the ichneumon-fly group. Combined length of head and body (exclusive of antennae) 3/16 of an inch. This pinned Illinois specimen in the Survey collection represents a species previously unrecognized. It probably parasitizes a moth larva. (Photo by Dr. LaBerge.)

portant group of the latter are the ichneumon-flies; over 1,000 are known to occur in Illinois and at least 30,000 occur in the world. None of these groups has as yet been studied intensively in the Midwest.

To get a start on the basic inventory of Illinois insect parasite "reserves," Dr. LaBerge has begun a detailed study of certain groups of ichneumon-flies. When material in the Survey collections was subjected to minute morphological analysis, it turned out that many more species occurred here than had previously been thought. In one small genus only four species are currently known in Illinois and eight for all of North America. Dr. LaBerge has now identified nearly twenty from North America, of which at least nine or ten are almost certain to occur in Illinois. Because each species has a different life history and host relationships, these and other new species segregates must be thoroughly diagnosed before biological information about them can be compiled and before precise experimental work can be attempted.

Fortunately investigators in many other parts of the world are studying ichneumon-flies of different areas. They also are finding new characters and new species, many of them parasitizing the same world-wide economic pests that occur in Illinois. The stage is gradually being set for a most interesting and hopefully profitable new approach to biological insect control.

Father of Rivers

As the Upper Mississippi River was developed for more reliable investigation serving the industrial centers of the country's heartlands, the increasing number of dams and locks turned the long even sweep of the river into a series of interconnecting long linear lakes separated by short stretches of rapids. This change produced many fish and wildlife problems having a profound effect on the use and development of recreation and conservation programs associated with the river.

For 900 miles of its length, from Hastings, Minnesota, to Carruthersville, Missouri, the Upper Mississippi has a different state on each side. It was obvious that only a concerted interstate cooperative effort could solve problems concerning the wise use of this river resource. Among early advocates of such an organization was the late T. H. Frison, former Survey chief. In late 1943 this organization became a reality when 22 biologists from Illinois, Iowa, Minnesota, Missouri, and Wisconsin met at Dubuque, Iowa, and formed the Upper Mississippi River Conservation Committee (U.M.R.C.C.).

The Committee consists of representatives from conservation departments of the five member states and the Natural History Survey, cooperating with several federal organizations and such state agencies as sanitary water boards and pollution control groups. Working through interagency subcommittees or sections on fish, game, recreation, law enforcement, pollution, and publications, the Committee makes recommendations on conservation laws, programs and legislation to the governing state bodies and the federal government.

In January of 1969 the Committee celebrated its twenty-fifth anniversary and at its annual meeting in Springfield honored its five surviving charter members, including Dr. George W. Bennett of the Natural History Survey. The Committee is indeed to be congratulated and commended for its guiding hand in developing the natural and recreational resources of the Upper Mississippi River.

The Wildlife Pesticide Situation

Having the dual responsibility of providing recommendations for the control of economic insects, plant diseases and certain other pests, the Illinois Natural History Survey as a whole has been deeply involved in the relationship between long-lived pesticides such as the chlorinated hydrocarbons (DDT, aldrin, and so on) and human and wildlife values in Illinois.

When one looks at the economic and demographic features of Illinois, it is obvious that the state is unusual in many respects. It is only a medium to small-sized state, yet ranks fourth in population. It has an enormous industrial development, yet also ranks fourth in agriculture production. Land values are extremely high,

U.M.R.C.C. chairman John Brasch, Wisconsin, presenting Dr. Bennett with his charter member award at the Committee's annual meeting at Springfield. (Photo provided by U.M.R.C.C. member A. C. Lopinot, Illinois State Department of Conservation.)

hence only increasingly intensive farming methods stand a good chance of realizing financial profits. As a result, no matter what the farm product, farm operators need effective fertilizing programs and weed and insect control to insure the success of their investments.

The opposite side of the coin includes the increasing need of a burgeoning population, especially in the cities, for the healthy type of recreation that only outdoor activities can provide. With the lowest ratio in the nation of available outdoor recreation space per unit of population, it is imperative that Illinois preserves and develops these wildlife resources to the maximum.

To devise means of obtaining maximum pest control and at the same time safeguarding the wildlife values of the state, in 1964 the Survey formed its Wildlife-Pesticide Coordinating Committee, composed of the chief and the heads of the five scientific sections. In its last meeting held December 12, 1968, the Committee reviewed the pesticide recommendations proposed for 1969. The chief change in pesticide recommendations made by the Botany and Plant Pathology Section was the deletion of DDT from the control recommendations for Dutch elm disease and phloem necrosis. Dr. Carter pointed out that the fungicides being recommended for the control of plant diseases have not been implicated as agents of undesirable environmental pollution, but that many of these compounds are toxic to at least the white rat. Little if any investigation of the action of these compounds on animal populations in the field has as yet been made.

Speaking for the Economic Entomology Section, Dr. Luckmann pointed out that there has been a remarkable decrease in the situations for which chlorinated hydrocarbons are being recommended for farm use. Current recommendations stress that no chlorinated hydrocarbons be used on dairy farms, on feed for dairy cattle, for the control of resistant corn rootworms, or for any pests of pumpkins or soybeans, to name a few of the more important points. The Section is distributing a set of rigid recommendations for the protection of the operator and for the avoidance of specific high-toxicity situations that occasionally arise.

None of the compounds being recommended by the Aquatic Biology Section are known to have long range deleterious effects in the environment. Dr. Larimore pointed out that there is not a firm experimental basis for making these assumptions. At the present time aquatic weed control is highly localized and pretty much in an experimental stage. Speaking for the Wildlife Research Section, Dr. Sanderson pointed out that the chemicals being recommended for the control of mammals, chiefly rodents, are used extremely locally and may involve only individual barns, houses, and stores.

Discussion centered chiefly around the fact that the long-lived insecticides are

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a continuing problem of world-wide significance. By now it has been established that DDT is present in minute quantities over the entire land and water areas of the world and in ultra-minute quantities in the air. Certain insecticides such as DDT may reach high levels in animals at the summit of the food web, until the animals are unable to reproduce. We do not yet know the physiological effect of these compounds on most species of life, including man.

Concerning man, the U.S. Public Health Service has reported that after two decades of use, there is no evidence that DDT has caused any problems in human health, and found that the amount of DDT in human fat had decreased countrywide 60 percent from 1955 to 1963. These figures tally with Survey findings in Illinois.

From an emergency standpoint DDT and related compounds are the most economical and effective ones available to protect crops and to control insect vectors of organisms that produce many of man's most serious diseases. Therefore it is difficult at present to ban these compounds, but it is advisable to reduce their use whenever and wherever possible.

From the discussion of these topics, the Committee reached three conclusions:

- Pesticide recommendations being distributed by various Survey sections are going in the direction of decreasing the amount of long-lived pesticides in the environment and for this reason are laudable and approved by this Committee.

- The long-range aims of chemical insect control should still be the use of more specific and less stable chemicals applied at the time and place where needed at the absolute minimum dosages and only when needed. These aims are the basis of the Survey's continuing studies in non-chemical insect control and its season-long monitoring of economic insect populations.

- Whereas many pesticides in use, particularly certain fungicides and possibly some aquatic herbicides, have been shown by laboratory tests to be toxic to wild species but have not been adequately tested on wild populations, we feel that it is desirable to learn more about the long-term effect of these compounds in the environment.

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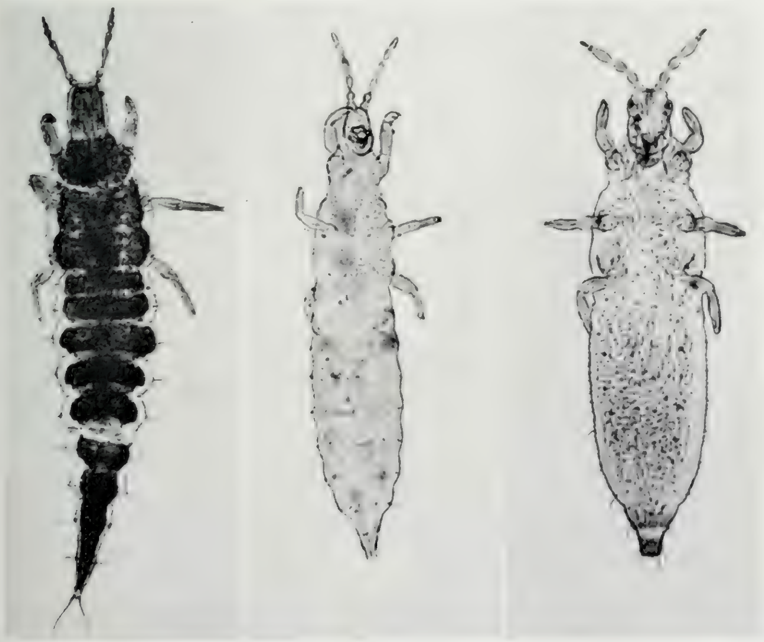
The Little Ones Count

In many groups of insects our classification is based on the adult stage, which may be a beetle, moth, fly, or grasshopper. Knowledge of the young stages, the larvae or nymphs, lags far behind that of the adults. The reasons are simple. The young stages very frequently exhibit far fewer obvious differences, so that even if we have them available for study it is not easy to identify them, and in most groups it is extremely difficult to associate the immature and adult stages because the insects are hard to raise in the laboratory.

This circumstance has been especially true of the thrips, the insect order Thysanoptera which Survey entomologist L. J. Stannard recently treated for Illinois and the Midwest. Of the 200 species known for the state, immature stages were associated with only a small handful. In recent developments concerning the insects harmful to soybeans in the Midwest, it was found that at least some thrips transmit a virus disease that could be of considerable economic importance. There is also mounting evidence that the immature stages of the thrips may be the important forms in transmitting the disease organisms from plant to plant. Now came the rub. To assess thrips populations properly it was necessary to find some way of identifying



Immature stages of three kinds of thrips. These represent three major types and there are many species very similar to each one. Longest specimen, ⅛ inch long. (Photo by Survey photographer Wilmer Zehr.)

the immature stages to species but none was known.

To solve this problem Dr. Stannard is now making a detailed study of young thrips. They are so unlike adult thrips in structure that the first task will be seeking a brand new set of characters that can be used for their recognition. Equally important will be efforts to establish laboratory colonies of various species in order to associate the young and adult stages. Dr. Stannard is in hopes that the more sophisticated rearing equipment now available will enable him to make steady progress in this endeavor.

Cottontail Ups and Downs

One of the most frustrating tasks of the wildlife research investigator is to obtain reliable information on the long-term, year-to-year fluctuations in wild animal populations. It takes a lot of manpower, ingenuity, and leg work to make a continuing census of even a small part of a state, let alone a full state. Frequently figures are not available for contiguous states, and if they are a different kind of census method may have been employed in adjoining states. As a result it may be difficult to equate measures of abundance and scarcity as determined by the different methods.

This situation has been especially difficult concerning the ups and downs of rabbit or cottontail abundance in the Midwest. Many conflicting statements have been made, and there has been an especial disagreement as to whether or not rabbits fluctuated regionally or locally through the central part of the continent. In an effort to bring some order out of the many reports available, former Survey wildlife specialist J. A. Bailey undertook to gather information from Illinois, Indiana, Kentucky, Michigan, Minnesota, Missouri, New York, Ohio, and Wisconsin from 1950 to 1965. Using many statistical devices helpful in equating values determined by different census methods, Dr. Bailey established beyond much doubt that cottontails do indeed fluctuate regionally in the Midwest. The figures indicate that there is local variation in abundance but that over the area as a whole the march of numbers is remarkably consistent. 1950 marked almost a normal or average year for cottontails. They hit a low in 1951 through 1954, then started climbing with several years of abundance, again dropping in 1959, with sub-average populations from 1960 to 1965.

In the 1930's and 1940's wildlife researchers had noted correspondence of the periods of scarcity of both cottontails and ruffed grouse in the northern part of the Midwest, leading to the surmise that the two animals responded equally to whatever conditions caused the fluctuations, and that one could be used as an index of the other. If true, this would have had important predictive value. Dr. Bailey found, however, that when the comparisons were run from 1950 to 1960 the opposite was true — when cottontails were abundant ruffed grouse were scarce, and vice versa.

Knowledge of the reasons causing fluctuations in cottontail abundance would give us not only a predictive tool but would undoubtedly open up new and profitable types of cottontail management. These reasons, however, are undoubtedly complex, including weather, land-use changes, disease, and other factors. This assessment of the regional fluctuations will give us a first toe-hold in trying to find out if these can be correlated with regional changes in weather or environment. If this can be done, it would help to isolate the local factors and make them more accessible to study.

Offbeat Glads

Every year new kinds of fungicides appear that manufacturers and growers hope will do a more thorough job in protecting various kinds of commercial plants from fungus diseases that affect them. The control of these diseases is especially important in a high cost-per-acre crop such as gladioli, and each year Survey plant pathologist J. L. Forsberg tests the more promising new fungicides on various varieties of glads.

In 1968 he treated eight varieties of glads with several new fungicides for the control of corm rot fungi, including a new

Multiple corms produced by some of the gladiolus plants treated with one of the systemic fungicides. (Photo by Dr. Forsberg.)

systemic compound that is absorbed into the plant and attacks the fungi in the living tissues. When he tabulated his results after the end of the season, Dr. Forsberg found that this new systemic fungicide had produced some very peculiar effects on two of the eight varieties.

Normally a small glad bulb or corm of the size used in these experiments would flower and produce only one larger corm above the old shriveled one. In these two varieties a considerable number of the plants did not flower but produced several corms. It is obvious that the systemic fungicide had produced internal changes in the abnormal plants. The question immediately arises: Is this an advantage or a disadvantage to the grower? He gets more corms faster but less bloom.

Next summer Dr. Forsberg will plant the corms from these abnormal individuals and see what happens. If the effects of the systemic altered the growth pattern of the plants only temporarily, this may indicate a new way to increase the production of glad corms. If the flower-depressing effect of the systemic is permanent, the situation would be disadvantageous.

Cereal Leaf Beetle

Four years ago this pestiferous little beetle was first found in northeastern Illinois. A European immigrant, it had become established in northern Indiana and Michigan and had locally practically denuded the small grains in those areas. Efforts were immediately made to suppress or eradicate Illinois areas known to be infested with this beetle.

This species overwinters in a shiny blue and orange adult stage, about one-fourth inch long, sheltering in a great variety of situations. In spring the adult flies to grain fields where it lays its eggs in May. The larvae occur in late May and early June, feeding on the grain foliage. Pupation and adult emergence span late June and early July. After emergence is a period of active flight after which the beetles seek out sheltered spots where they pass the late summer, autumn, and winter. A certain amount of dispersal occurs in their July flights but it is believed that most long-distance jumps are passive ones in items of commerce which are shipped from infested areas. The adult beetles are unusually prone to shelter in baled hay, unshelled corn, sod, and stored small grains.

After observing the cereal leaf beetle in Illinois for four years, Survey entomologist W. H. Luckmann reports that it should not necessarily be considered a disaster-type pest. Economic damage from the beetle can be kept low by early planting and fertilization of its chief Illinois hosts — oats, wheat, and barley. Under these conditions small areas may develop heavy populations that will need surveillance and

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local control measures, but most fields will grow away from the beetles. He points out that the real potential threat of the beetle from a national viewpoint is what it might do in the extensive barley and wheat growing areas to the west.

The federal government is trying two methods of preventing westward spread of the beetle. First, in cooperation with the Illinois State Department of Agriculture it is attempting suppression control of the beetle on known infested areas, using special ultralow volume Malathion sprays. These have been successful in apparently annihilating the beetles from two counties in the state. Where the beetle persists, a quarantine is imposed on the movement of baled hay, unshelled corn, sod, and small grains. Before it can be taken out of the quarantine area the hay must be fumigated and the other commodities treated with insecticides.

At present parts of 13 Illinois counties are quarantined, forming a scattered series of areas in central and eastern Illinois, extending from Shelby County to Cook County.

To keep track of this pest, an intensive cereal leaf beetle hunt will again be conducted throughout the state as a cooperative effort with the U.S.D.A., the Illinois State Department of Agriculture, and the Natural History Survey. Identifications will be checked by Survey entomologists M. W. Sanderson and J. K. Bouseman. Infested fields will be treated with Malathion this spring by USDA and Illinois Department of Agriculture personnel and next fall a re-assessment of the areas to be quarantined will be made.

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Integrated Insect Control

In the years since World War II, the development and use of insecticides for control of most of our important insect pests progressed so rapidly that other methods of insect control were practically forgotten. Recent concern over pollution of the environment by the wholesale use of toxic chemicals, however, has focused attention on other means of insect control. One of these, biological control, involves the introduction of insects or other organisms that feed upon or parasitize economically important insects.

As if there were not enough insect pests native to the U.S., occasionally one is introduced into this country from the Old World and spreads rapidly, becoming a major pest almost overnight. A prime example is the alfalfa weevil, *Hypera postica*.

Adult and cocoon of *Bathyplectes curculionis*, a small parasitic wasp that may help control the alfalfa weevil. (Photo by Survey Photographer Wilmer Zehr.)

This small weevil is a native of the Old World, but is not a serious pest in those areas because of the presence of parasites and predators that serve to keep weevil populations at relatively low levels. The absence of these predators and parasites in the U.S. has enabled alfalfa weevil populations to build up to the extent that it is now the most important pest of alfalfa in this country.

A western strain of the weevil, first discovered in Utah in 1904, spread through most of the country west of the Mississippi River with the exception of Texas and Minnesota. An eastern strain was identified in Maryland in 1951 and has now been found in every state east of the Mississippi except Florida. Destruction of alfalfa by the alfalfa weevil is so extensive that losses in the U.S. now exceed $56 million yearly.

First found in Illinois in 1964 by former Survey entomologist R. J. Dysart, the alfalfa weevil is now present in all counties in Illinois and is economically important south of a line from Champaign to St. Louis.

To combat the alfalfa weevil in the U.S., two methods are being used, chemical control with insecticides and biological control by the introduction of parasites from the old world. Over 300 releases of 10 species of alfalfa weevil parasites have been made in 20 states, including Illinois. Athough none of the parasites released in Illinois have become established, a small wasp not native to the state has become established throughout Illinois and into Wisconsin. Further investigation by Survey entomologist Ed Armbrust, revealed that the wasp,

known as *Bathyplectes curculionis,* was introduced into Kentucky and moved into Illinois with the alfalfa weevil as it spread northward. The fact that the parasite is now well established in Illinois and has been known to parasitize up to 70 percent of alfalfa weevil larvae in other states, gives this small wasp a very promising future as a biological control agent.

According to Dr. Armbrust, *Bathyplectes* parasitizes alfalfa weevil larvae and forms a cocoon within the cocoon formed by the weevil larva. Since the weevil larva is killed and no adult weevil emerges the following year, the logical impact of parasitism should be a reduction in adult weevil populations the following season. Although such a reduction has been observed, Dr. Armbrust also found a significant reduction in the amount of damage caused by larval feeding in alfalfa fields where there was a high degree of parasitism. Research is now under way to find out why the parasite has an effect on larval feeding even though the larva is not killed until the cocoon stage.

Although biological insect control sounds wonderful, parasites and predators of economic pests do not usually give enough insect control to do away with insecticides entirely. A much more logical approach is to combine insecticide application and biological control together in an integrated insect control program. This is exactly the approach that Dr. Armbrust is taking in cooperation with other entomologists from the neighboring state of Indiana. Through carefully planned research, they hope to find out which insecticides can be used against the alfalfa weevil with a minimum amount of harm to the wasp parasite. By studying the life history of the parasite they may be able to select an opportune time when insecticides will be effective against the weevil but not the wasp.

Where would all this lead? Hopefully a program can be developed in which biological control by the parasite will assume a major role in keeping weevil populations at a low level. This would permit the grower to use less insecticide or fewer insecticide applications and still get satisfactory control of the alfalfa weevil.

Pollution Effects on Bluegills

Man's ability to control or modify his environment is often hailed as a sign of his great intelligence and mastery over nature. Unfortunately, man's ego has caused him to see things in terms of his own personal needs. He has developed chemicals to control pests and weeds which interfere with the production of foods and fibers at the lowest possible cost. He has dumped his refuse into lakes and streams where it disappears from his sight. "Out of sight; out of mind," the saying goes. Only recently is man slowly becoming aware that his actions may have subtle effects on his environment which may be irreversible as well as undesirable. The growing need for fresh, clean water is causing man to take a close, hard look at the effects of pollution on the supply of high quality water for future years.

Water quality depends to a great extent on the actions of aquatic flora and fauna. Whenever a pollutant enters the water, man may not be directly affected by its presence unless he uses the water for some purpose. Aquatic animal life or fauna, on the other hand, may be seriously affected by the presence of the pollutant because of their immersion in the water and their constant exposure to the pollutant. If the pollutant passes quickly down a river, or the level is relatively low, the aquatic fauna may not be seriously affected. However, if the pollutant is in slow moving water or in a pond or lake, exposure time may increase and the fish and other animal life may be adversely affected. This in turn may alter the quality of the water over a period of time.

Several years ago, research was initiated by the Illinois Natural History Survey to estimate the effect of possible pollutants on aquatic organisms. One such study, conducted by Survey biochemist R. C. Hiltibran, utilized the bluegill as an experimental animal. Since it was known that many substances can greatly alter respiration and thereby severely alter energy production within animal tissues, Dr. Hiltibran began a study of the effect of possible pollutants on energy production by bluegill liver systems.

One of the first research findings was that heavy metals such as cadmium and zinc, which are components of waste from manufacturing plants, severely altered energy production by bluegill livers. Further investigations revealed that some derivatives of the herbicide 2-4-D, which is used in great quantity in agriculture, were highly toxic to bluegills. It was found that the more toxic derivatives of 2-4-D also altered energy production and a correlation existed between their toxic effect and their effects on energy production.

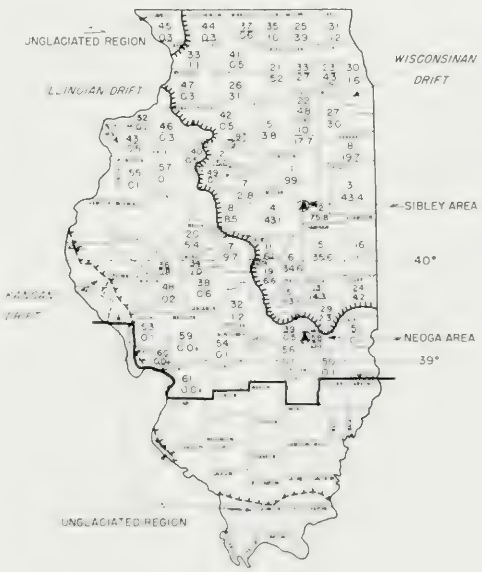
Recently the effects of organochloro insecticides on the energy production by bluegill liver systems were investigated. According to Dr. Hiltibran, toxophene, methoxychlor, and heptachlor, which are extremely toxic to bluegills, severely altered oxygen metabolism in the bluegill liver tissues. Aldrin and dieldrin were less effective. Also it was found that the organophosphate insecticide parathion altered oxygen uptake more than did the organochloro insecticides mentioned above. It is possible, therefore, that the lethal effects of these insecticides on bluegills and other fishes may be due to their effect on energy metabolism.

Further research of this type will give man a better insight into the less obvious effects of environmental pollution and may help him to change or modify his actions so that the world will still be a fit place to live for future generations.

Prospecting for Pheasants

In Illinois, the pheasant is most abundant on the mantle of glacial drift deposited by the retreat of the state's last ice sheet about 15,000 years ago. This drift from the Wisconsinan ice sheet is restricted to the northeastern third of the state, as shown on the accompanying map. Few pheasants are found in the western and southern counties of the state where the exposed glacial drift was left by the Illinoian ice sheet some 80,000 years ago. The pheasant's seeming dependence on geologically young soils, in Illinois and elsewhere in the Midwest, raises the question as to why the older soils do not support large pheasant populations. One hypothesis is that a deficiency or surplus of certain minerals in older soils, such as the Illinoian drift, that have been subjected to mineral weathering and leaching for a much longer time, may be restricting pheasant populations in these areas. An imbalance in minerals seemed particularly likely on the pheasant-poor, Illinoian-aged farmlands of south-central Illinois, which otherwise appeared capable of supporting larger pheasant populations.

To gain insight into this puzzling ecological problem, Survey wildlife specialists Ronald F. Labisky and William L. Anderson, in collaboration with the University of Illinois soil mineralogist Robert L. Jones, set out to monitor the flow of selected minerals from soils to plants to pheasants on both the Wisconsinan and Illinoian drifts. To accomplish this, concentrations of four essential elements — sodium, potassium, calcium, and magnesium — were measured in soils, in seeds of corn and Chinese foxtail which serve as foods for pheasants, and in pheasant flight feathers from two areas of contrasting pheasant abundance in Illinois. The low-density pheasant population was located



PHEASANT ABUNDANCE
APRIL 1963

COUNTY RANK

PHEASANTS PER 100 MILES
OF DRIVING

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on the geologically older Illinioan drift near Neoga and the high-density population on the younger Wisconsinan drift near Sibley (see map).

Potassium, calcium, and magnesium were found to be less abundant and sodium more abundant in Illinoian drift soils than in Wisconsinan drift soils. Magnesium was more abundant in corn and potassium was more abundant in foxtail on the Illinoian drift. Higher concentrations of sodium, potassium, and magnesium were found in feathers from pheasants on the Illinoian drift than from those on the Wisconsinan drift. Thus, differences in the concentrations of these elements in soils were mirrored neither by levels in plant seeds nor in pheasant feathers. If pheasants were suffering from a deficiency of calcium, potassium, or magnesium on the more weathered Illinoian drift, the deficiency was not reflected by the mineral composition of their feathers. However, high sodium to potassium ratios in soils, plant seeds, and feathers on the Illinoian drift, in contrast to the Wisconsinan drift, might indicate a nutritional imbalance. The differences in these mineral ratios and their effects on pheasant populations are subjects of continuing studies on pheasants by Survey wildlife specialists.

These findings are presented in a recent Natural History Survey Biological Note (No. 63, December 1968), entitled "Selected Minerals in Soils, Plants, and Pheasants: An Ecosystem Approach to Understanding Pheasant Distribution in Illinois," by Robert L. Jones, Ronald F. Labisky, and William L. Anderson. Copies are available on request.

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MAY 1969, NO. 79

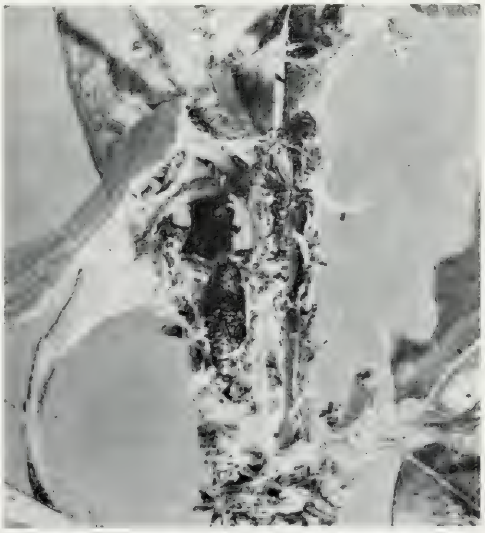
Leaf Crumpler Losing?

For effective control of an insect pest, one should know its life cycle and understand the pest-parasite relationships as well as the means of chemical control. Survey entomologists H. F. Pierce and J. E. Appleby are conducting such an integrated study on a pest of rosaceous plants—apple, pear, cotoneaster, quince, cherry, hawthorn, and so on — occurring throughout Illinois. This pest is the leaf crumpler (*Acrobasis indiginella*).

This insect does its damage only as a larva which lives in a small trumpet-shaped case made of fecal pellets glued together by silk threads and covered with dried leaves. The larvae venture out of their cases at night only long enough to drag foliage to the entrance where they feed. The adult moth appears in mid-July and lays about forty eggs. The young larvae hatch in about nine days and soon begin to feed and build cases. Feeding continues until cold weather, at which time the larva closes the case entrance and remains dormant until leaves appear in the spring. Damage is most readily seen in winter when the cases are not hidden by foliage.

In studying the life history of the leaf crumpler, large samples of larvae were brought into the laboratory and reared. Parasitic flies and wasps were produced from many of these samples. These parasites include a tachinid fly (*Nemocilia pyste*), an ichneumon wasp (*Pimpla annulipes*), and four chalcidoid wasps (*Dibrachys cavus, Perilampus fulvicornis, Eupelma cyaniceps,* and *Pediobius sexdentatus*). Of the last four, some may be hyperparasites — for instance, *Perilampus* — that is, parasites of one of the larger parasites. A complex scheme of host-parasite-hyperparasite relationships is emerging from these studies. Life-history and parasite studies of this nature could lead to successful biological control of a pest. *Dibrachys cavus,* for example, can be reared in large numbers in the laboratory.

Another area of study being conducted by entomologist Pierce is chemical control of the leaf crumpler. Various chemicals of low toxicity to birds and mammals have been tested. The life-history studies have shown that the only effective time to apply chemical control methods is in the spring or fall when the larvae are actually feeding. The effect of these chemicals on



Leaf crumpler in cases showing silken webbing, dried leaves, and leaf damage. (Photo by Survey photographer Wilmer Zehr.)

the parasites are also being studied. Additional chemicals will be tested this season and recommendations as to the best control method will result.

An integrated control program involving the best methods of biological control and chemical control based on a thorough study of the ecology and habits of the pest and its parasites should result from these studies.

Oxbow Soup

As a river meanders through its floodplain, it occasionally may change its course, cutting off small sections of the original channel which are known as oxbow lakes. These lakes again may be connected with the river during brief periods of high water. Dr. R. W. Larimore, aquatic biologist for the Survey, observed that many of the typical river fishes also occurred in the oxbow lakes. When the fishes of these pools were studied more closely, it became apparent that many of them were using the oxbow lakes as breeding grounds.

Plankton (microscopic, floating plants and animals) supplies the basic food items for young fishes, so it was interesting to learn how the plankton of the floodplain pools differed from that of the river. Professor Kofoid, in his classic study of the plankton of the Illinois River published by the Survey in 1903, pointed out the importance of the floodplain lakes in the development of the plankton of that river.

An ideal area for a comprehensive study of the relationships of the floodplain pools to the Kaskaskia River was found about 60 miles from the river's source. In this area are fourteen pools which are connected to the river during periods of high water. A study of the plankton in the Kaskaskia and in two of these pools was begun by Ed Doyle of the Survey's Aquatic Biology Section in 1967.

The basic plankton in the aquatic food web are the microscopic plants (phytoplankton) that usually float in the upper layers of water. Biologist Doyle found that the phytoplankton of the Kaskaskia River consisted mostly of bottom-living diatoms that are swept into the water column by the current, while the phytoplankton of the floodplain pools was dominated by surface-living, single-celled flagellates of the family Euglenophyceae. Only a small number of diatoms, the dominate form in the river, was present in the oxbows.

The phytoplankton are fed upon by microscopic animals (the zooplankton) which, in turn, are fed upon by very small fish. The Kaskaskia had a relatively low zooplankton population, continually dominated by rotifers. The zooplankton of the floodplain pools was numerically much larger and more diversified. In one pool, copepods — microscopic crustaceans related to crayfish — were the dominant zooplankters. In another pool, copepods were again important, but ostracods and cladocerans (other crustaceans) and rotifers were also important. The average number of zooplankters per liter of water in this pool was more than ten times greater than that of the river. With definitely more food for young fish in the oxbows than in the river, it is advantageous for fish to spawn in these pools. During floods, plankton washed into the river from the oxbows momentarily increased the river food resources for small fishes.

Documentary Fishes

One of the responsibilities of the Natural History Survey is in providing accurate identification of specimens, for it is first necessary to know what the animal or plant is before other information can be furnished. This responsibility is assumed by the Survey's Section of Faunistic Surveys and Insect Identification.

Because of the large numbers of animal species in Illinois, the specialists who must identify the animals submitted need collections of named specimens with which they can compare the unknown specimen. The collections are perhaps of even greater importance in serving as raw materials for basic research in studies of classification and evolution and in documenting information published in technical reports.

Of the Survey's collections, one of the oldest and most famous is the fish collection. There are extensive series of Illinois fishes collected before 1900 upon which the classic and out-of-print *Fishes of Illi-*

Prairie chicken hen on nest in blackberry bramble and grass. (Photo by H. E. Hesselschwendt.)

nois was based. These nineteenth-century specimens are extremely valuable since they were utilized in the descriptions of several new species. The largest part of the collection has been assembled by ichthyologist P. W. Smith and his associates since 1960 as the basis for a new *Fishes of Illinois*, now in preparation, which will stress changes that have occurred in Illinois waters and fish populations over the past seventy-five years.

The collection, containing more than a quarter of million fishes, is widely used by students and scientists throughout this country. Each year several investigators visit the Survey to study material in the collection and many others borrow our specimens or request information about certain fishes. It is gratifying to note that almost every study published on the fishes of eastern North America acknowledges the aid of the Natural History Survey and cites specimens deposited in our permanent collection.

Prairie Chicken Decline Halted?

By the fall of 1962 only about two thousand prairie chickens remained in Illinois and this population was declining rapidly. The first prairie chicken sanctuary in Illinois, the seventy-seven–acre Ralph E. Yeatter Sanctuary northeast of Bogota in Jasper County, was dedicated on November 12, 1962. This sanctuary was purchased by the Prairie Chicken Foundation of Illinois, a nonprofit organization dedicated to the purpose of saving the prairie chicken from extinction in Illinois. The Natural History Survey together with the Illinois Department of Conservation initiated a prairie chicken research program in the summer of 1963 to study these birds. This research has indicated the importance of the kinds of vegetation on nesting sanctuaries needed to provide proper habitat for nesting prairie chicken hens.

Prairie chicken males congregate on booming grounds — so-called because of the sounds they make while performing a dance on certain open areas. The function of the booming ground is not fully understood, but the proximity of nesting cover to the booming ground is important.

Recent research by Survey Wildlife biologist Ronald L. Westemeier indicates that, when given a choice, prairie chicken hens select nest sites about 240 yards from the booming grounds in a fairly uniform pattern resembling the spokes of a wheel. This indicates that a forty-acre sanctuary with a five-acre booming ground at its center could support ten or more nests located

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240 yards from the booming ground and 120 yards apart. This information is important in the management of the nesting sanctuaries because of the limited acres available.

Since 1962 several Survey scientists have given continued support to the Prairie Chicken Foundation of Illinois in its attempts to acquire land and convert it to sanctuaries. This foundation now owns or controls 297 acres in four sanctuaries near Bogota in Jasper County. Survey scientists have also worked closely with a second organization formed in the fall of 1965, when it became obvious that the job of saving the prairie chicken was too big for one organization. The second group, the Prairie Grouse Committee, is associated with the Illinois chapter of the Nature Conservancy. Glen C. Sanderson, head of the Survey's Section of Wildlife Research, reports that the Prairie Grouse Committee has purchased, has had donated, or has leased with the promise of donation 390.3 acres in five sanctuaries in Jasper County and 420 acres in three sanctuaries near Farina in Marion County. In addition, the Illinois Department of Conservation is leasing ninety-eight acres of grass and legumes as a holding action until an adequate refuge system can be completed.

Wildlife biologist Westemeier reported that in the spring of 1968 no more than 300 prairie chickens remained in Illinois. Final figures for 1969 are not yet completed, however, one encouraging sign is that the decline has seemingly been halted in the Bogota flock in which there has been a 25 to 35 percent increase since the spring of 1968. Also, it appears that the Farina flock can still be saved if sufficient land is acquired soon enough.

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JUNE 1969 NO. 81

To Catch a Bluegill

Many bluegills are caught in lakes by fly-fishing and others by still-fishing from the shores, but one of the popular techniques for catching bluegills in lakes during the hot summer is by trolling with live bait in deep water. At Lake Glendale in southern Illinois, where the maximum depth is 22 feet, some fishermen troll for bluegills at depths below 10 feet with great success.

A common notion among sport fishermen is that bluegills and certain other fish go to deep water in the summer because of the lower water temperature. In most lakes there is a layer of water known as the thermocline. Above this layer temperatures are warm, even hot, but below it temperatures drop rapidly. In midsummer the thermocline starts at about 10 feet but shifts up or down 2 to 3 feet with changes in air temperature. The belief that fish look for cool temperatures in the summer is also commonly accepted among fishery scientists, although a few maintain that factors such as light, clearness of water, plant cover, and food abundance at various depths are important as well as water temperature. That fish prefer low temperatures is not supported by laboratory observations which show that, when other factors are controlled, bluegills prefer a temperature of 90 degrees Fahrenheit.

To shed some light on this puzzling problem, Survey aquatic biologist D. F. Hansen recently made a comparison between depth of capture of bluegills and the observed water temperature at various depths at Lake Glendale. The fish were caught on trotlines suspended vertically from plastic floats. Hooks were attached to the lines at one-foot intervals, baited with worms, and checked each hour for fish or stolen baits. When the trotlines were fished in the deep part of the lake, fish were caught at most depths and each time a fish was caught its length and the position of the fish on the trotline were recorded. At certain times in the study the stomach contents of the captured fish were examined to see what fish caught at various depths had eaten.

Two happy Illinois fishermen with a good catch of bluegills. Can you guess the year? (Photo by former Survey editor James S. Ayars.)

From this study Dr. Hansen concluded that temperature preference has relatively little to do with the summer depth distribution of bluegills in Lake Glendale. Over short periods of 2 to 14 days fishing time, during which changes in water temperature at different depths were minor, bluegills were caught near the surface where temperatures were as high as 86 degrees Fahrenheit as well as in deep water as cold as 56 degrees Fahrenheit. Most of the fish were taken in water ranging from 72 to 79 degrees Fahrenheit, but on one occasion many bluegills were captured in water at 65 degrees Fahrenheit. Marked variations in water temperatures brought on by the sudden air-temperature changes that occur with the passing of weather fronts were not followed by radical changes in bluegill depth distribution. Thus the preference of bluegills for certain water depths appeared to be at least partially independent of water temperature.

Since water temperature did not fully explain bluegill presence at different depths, a study was made of stomach contents to see if feeding habits were involved in bluegill distribution in the lake. This study showed that, while fish were feeding to some extent on such food as snails and dragonfly nymphs that live on or among aquatic plants close to shore, the most heavily used foods were midge larvae, which live on the lake bottom, and animal plankton, which occurs at most depths in the open waters. Bluegills caught near the bottom contained more midge larvae, and those caught at 12 to 15 feet below the surface contained more plankton than any other food. Since the same fish stomachs often contained foods from the weed beds as well as foods which had definitely been eaten in the open waters, it is clear that the same fish were feeding in both locations within a 24-hour period.

Although several published studies have indicated that the bluegill is primarily a shoreline feeder, the present study shows that the heaviest feeding by bluegills is done in the open water. Trotlines fished near the shore in water 7 feet deep caught fewer fish than those fished at 20 feet during the same time period. Fishing for bluegills at depths of 10 feet or more in the open water, therefore seems to offer the best opportunity for catching bluegills during the summer in Lake Glendale. The same may be true for other lakes.

Moldy Waters

Microscopic plants called fungi or molds are present practically everywhere in our environment. In terrestrial or land habitats, fungus spores are produced in great abundance and can be recovered from animals, plants, air, soil, and water. Until recently, however, it was generally assumed that, except for a few specialized forms, fungi were an insignificant part of the living organisms of streams and other bodies of water. The increased interest in the effects of pollution on our lakes and rivers has motivated scientists to take a closer look at the aquatic fungi.

Improved techniques for isolating fungi have enabled scientists to discover that many fungi formerly thought to be confined to a terrestrial environment are actually common members of aquatic populations. Furthermore the fungal population of any body of water appears to fluctuate depending upon the physical, chemical, and biological conditions of the water.

Preliminary work done on the Mississippi and other rivers by Survey mycologist Leland Crane, indicates that fungus species commonly found in clear water with little or no pollution are markedly absent from water with a high percentage of organic matter. In addition, certain species appear to be associated with polluted water whereas others can be found in both clear and polluted waters.

At present Dr. Crane is conducting a study at five stations along the Mississippi to determine more precisely the composition of fungus types occurring in the water at these locations. He is particularly interested in the fluctuation of the fungal populations with seasonal changes and the number of species isolated from the river which are known to cause diseases of plants or animals. Eventually, however, a variety of isolation techniques will be employed and correlations made between the

fungi encountered and physical and chemical properties of the water such as acidity, temperature, and dissolved oxygen content. Hopefully certain fungus species will be found that will serve as valuable indicators of water contamination for use in future pollution work.

Welcome Parasites

Patches of brown grass which are easily pulled loose with a rake often appear in lawns throughout the Midwest in middle to late summer. These usually indicate damage by one of the most common insect pests of permanent grass pasture, home lawns, and golf courses known as the sod webworm. The adult of the sod webworm is a small, light brown moth, which can commonly be seen flying out of lawns at twilight or when the lawn is being mowed. The damage, however, is caused by the feeding of the webworm larvae, which are about an inch long when full grown and live in silk and grass tunnels at the soil surface. Considerable time and money are spent each year to control this pest with lawn insecticides. Fortunately, like many other insect pests, webworm populations are kept under at least partial control by disease parasites.

Survey entomologists J. V. Maddox and A. C. Banerjee recently completed a study on the diseases of sod webworms and found four different diseases caused by tiny protozoan parasites called microsporidians. These microscopic animals are not free-living and can multiply or reproduce only in the cytoplasm of living insect cells. When the cytoplasm of the infected cell has been replaced by the multiplying microsporidians, tiny spores are formed. These spores are only one five-thousandths of an inch long and are very resistant to destructive forces, remaining in or on the soil and grass for long periods of time. When these spores are eaten by another sod webworm larva, they germinate and begin to multiply in the cytoplasm of the cells of that larva.

Most of the infected larvae die before they mature into adult sod webworm moths. However, some larvae with relatively light infections develop into infected adults. The infected female adults then transmit the disease through the egg to their offspring. All of the larvae hatching from eggs laid by infected females are infected with the parasite and one-half of the larvae hatching from these eggs die within one week. Very few of these larvae develop into adult moths, and those which do are infected and in turn transmit the disease to their offspring.

According to Dr. Maddox, the use of microsporidian diseases as control measures for sod webworms is not practical at the present time. These parasites, however, undoubtedly help to keep down the numbers of sod webworms which reproduce each year. Further study of the microsporidians may lead to their more effective use in controlling this pest. Any help would be welcomed by home owners plagued with sod webworm damage.

The Rare and the Unknown

To the average person, the word "insects" may suggest hordes of locusts laying waste to a wheat field or a cloud of mosquitoes terrorizing a camping trip. But not in all cases do insects occur in large numbers. Although it has been estimated that nearly one million species of insects have been described and classified by scientists throughout the world, the great majority of these species are composed of rare, relatively little known insects. Many such species are represented by only a few specimens residing in some obscure collection.

Since many different insects are present in the world, it is necessary for the entomologists to be able to identify accurately the species with which he is working and to have some knowledge of its relationship to other groups of insects. Keeping insect classifications up to date requires the constant study, description, and reclassification of preserved specimens. At present Survey entomologist D. W. Webb, in cooperation with graduate students W. Brigham and A. Roeske, is revising the genus *Hilarimorpha*, a group of flies for which only 134 known specimens exist. Prior to this study only seven species and twenty-six specimens had been reported

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throughout the world: two species (three specimens) from Asia; two species (16 specimens) from Europe; and three species (seven specimens) from North America. Through the cooperation of museums in North America as well as in Europe and Asia, specimens of all of these species have been borrowed and examined by Survey scientists along with the additional unidentified specimens. As a result, the Asian species have been removed as incorrectly classified. The two European species have been retained as well as the three North American species, to which will be added the additional descriptions of some twenty new species.

Unfortunately, nothing is known of the immature stages of these flies, thus little biological information has been recorded. From certain types of information reported with each collected specimen and from the biology known from some other closely related groups, it is assumed that the larval stages of the flies occur in bottom land areas but whether they are aquatic, semi-aquatic, or terrestrial is unknown. The discovery of the larval form would be of great help in determining the position of this group of insects genetically in relation to some of its close relatives. Since these flies are so rare, finding the larval form has proved to be most difficult.

Although this group of flies is small in terms of numbers, its revision is important in that it will greatly improve our knowledge of the interrelationship of certain closely related families of flies. Since its original description in 1860, this group has been placed in five different families of flies, and it is the untangling of its relationships with other flies that will provide us with a better understanding of the pathways of evolution in the insect world. The revised classification of *Hilarimorpha* will be published by Mr. Webb and his associates for use by other entomologists throughout the world.

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JULY 1969, NO. 81

Virus Disease of Gladiolus

Illinois is one of the leading states in the commercial production of gladiolus. With the development of controls for fungal and bacterial diseases, attention has been turned to the virus diseases of this specialty crop. The most important and frequently encountered of the virus diseases is called white break. This disease is caused by the cucumber mosaic virus which causes white splotches in the gladiolus flower petals from which the disease was named. Survey plant pathologists Walter Hartstirn and Junius L. Forsberg have devoted considerable effort to learn more about this and other virus diseases that have become important problems in the last two decades.

In their work doctors Hartstirn and Forsberg found that there is great variation in the susceptibility of the 67 varieties of gladiolus tested. Also stock planted early in May is less likely to have diseased flowers than stock planted late in June. This suggests that homeowners will have less of this virus disease in their plantings if they are started early in May than if they are planted in early summer.

The disease was not eliminated, but was held at low levels when diseased plants were pulled and destroyed. For commercial growers this might not be a practical procedure. Therefore, a study of the amount of virus transferred to the cormels (bulblets) of diseased plants was undertaken. The cormels are the main means of commercial propagation of varieties of gladiolus. In these tests 18 thousand cormels were planted in the greenhouse to produce corms that would flower in the next season. The results were highly variable with little disease transmitted from diseased parent plants to the offspring in certain varieties and much transfer in other varieties. The use of cormels to produce new stock, however, provides some control and should prove helpful to commercial growers.

During these studies it became apparent that the white leaf symptom was not a reliable indicator of the presence of the disease. Some varieties have leaves that are

White break symptoms show as white streaks and splotches on the normally dark red King David gladiolus. (Photo by J. L. Forsberg.)

normally partially white while other varieties will rarely produce the white leaf symptom when infested with the virus. The flower symptom proved to be the best indicator of the disease. But even this is difficult as less disease was noted in the white and yellow varieties than in others. Whether this was due to actual resistance or to the inability to detect the symptom in flowers of these colors remains to be established.

With rare exception, the disease will transfer from the diseased plants to the next generation of corms (bulbs). These plants may serve as a source of infection of the disease which then spreads to uninfected plants. The virus is transmitted from one plant to another by small sap-sucking insects called aphids. A complicating factor comes in when we realize that many cultivated and weed plants are susceptible to the virus causing white break. Aphids may carry the virus from these plants to gladiolus, which then become diseased. Of course, control of aphids by use of insecticides also helps in controlling the spread of the virus, but as the aphids may go to several plants, they are difficult to control. Consequently, the disease is not likely to be eliminated entirely until better methods of control are found.

Water, Oxygen, and Metals

For many years man has been using the air and waterways for removal of wastes. At first most of these wastes were of biological or natural origin. Nature handles such wastes in limited quantities superbly. As our technology increased and our cities became larger, products of unnatural origin increased among the generally increasing wastes products flushed down our rivers. While the aquatic environment could stand small quantities of heavy metals, for instance, larger quantities became detrimental to animal life. Heavy metals entered the lakes and streams from industrial and mining wastes dumped into or near the streams.

The possible effects of heavy metals on animals has incited the interest of many biologists and several hypotheses as to why they are toxic have been proposed. An early suggestion was that these metals, especially zinc, precipitated mucus at the gill surfaces of fishes and, thus, interfered with oxygen uptake or even blood circulation in the gills. There are data to support this idea. Others have suggested that cellular damage by interaction between the metal and cellular structures was involved. Recently, it has been suggested that fishes and other organisms exposed to heavy metals are subjected to stresses which induce tissue changes in essential organs.

Other evidence suggests more fundamental physiological effects for the heavy metals. For instance, heavy metals cause reduced oxygen uptake, reduced carbon dioxide output, changes in breathing rate, reduced growth and development. Also, the fish poison, rotenone, seems to have similar fundamental effects on physiology, rather than simply the physical effects previously thought to be important.

Survey biochemist Robert C. Hiltibran has been investigating the effects of several materials on the energy production by the bluegill liver mitochondria (minute bodies inside liver cells which are the sites of much metabolic activity). An early observation was that cadmium and zinc severely limited oxygen metabolism, whereas manganese and calcium were not so inhibitory. Further work indicated that cadmium altered oxygen metabolism more severely than did zinc. This suggests that the internal cellular effects of the heavy metals such as cadmium and zinc are more important in their toxicity to fishes than the previously suggested physical effects. Rotenone also appears to affect the oxygen metabolism in liver mitochondria at very low levels.

Fish and other aquatic organisms would be seriously affected and may even be killed, should the intracellular energy metabolism of an important organ such as the liver be severely depressed. Dr. Hiltibran also points out that other stream and lake pollutants which are toxic but do not seem to affect energy production by inhibiting oxygen or phosphate metabolism probably have other metabolic effects which must be searched out. A comprehensive picture of the effects of these pollutants not only may aid us in searching for means of coping

with them and improving our environment, but also contributes fundamental information regarding the metabolism of animals.

Fly Birth Control

A serious attempt is being made to control houseflies in the vicinity of farms and feedlots by the use of chemosterilants to reduce the fertility and, thus, the populations of flies. In 1968 Survey entomologist Robert D. Pausch and assistants tested the effectiveness of three chemical sterilants on four farms in different areas of the state. Results have been promising.

The sterilants were applied as sweet baits impregnated on cloth cords and hung inside poultry houses, barns, and the like, where flies would have ready access to them. The study areas were monitored each week to test the persistence of the sterilants and the degree of sterility in the fly populations.

Excellent control was obtained of the little housefly *(Fannia canicularis)*. On several occasions 100 percent sterility was obtained for periods of 10 to 15 days after the initiation of the experiment. In other experiments fertile flies were occasionally collected, but during some weeks it was impossible to check for fertility, as no adult little houseflies could be collected.

Effects on the common housefly *(Musca domestica)* were not as spectacular. However, an average of over 50 percent of all houseflies on all four test farms were found to be sterile throughout the entire fly season. Sterility ranged from a low of 24 percent to a high of 82 percent. No insecticides were used on the test farms in 1968, yet populations of the housefly were reduced on an average of 50 percent and as much as 82 percent, if sterility can be used as an index of control.

In laboratory tests on confined populations Dr. Pausch regularly obtained 100 percent sterility of the little housefly and between 85 and 90 percent sterility of the common housefly. More research and field studies are needed to improve the methodology of presenting the sterilant to natural populations of houseflies. Weekly analysis of sterilants used in 1968 showed that these are effective for up to 20 weeks in covered poultry and animal sheds and lounging areas. Thus, the development of a stable, attractive bait is essential in order to employ sterility technique of suppressing wild populations of flies in and around livestock buildings.

During 1969 the same four test farms are being used by entomologist Pausch, together with a feedlot in northern Illinois. The chemicals being tested are being varied and flies are being sterilized in the laboratory and released at two of the test sites. At the feedlot site a combination of insecticide and chemosterilant is being tested. It is hoped that the sterilization technique will help in reducing the ability of flies to develop resistance to insecticides and that a combination of the two control methods will be more effective than either alone.

Major J. W. Powell

Major J. W. Powell will be honored by the U.S. Post Office by a six-cent stamp to be issued on August 1, 1969, at Page, Arizona, to commemorate the centennial of Major Powell's trip through the Grand Canyon. Major Powell was the first man to lead a boat expedition through the canyon. His trip through the canyon was part of an expedition sponsored by the United States government to study the geology and natural history of the great basin states of Utah, Nevada, and Arizona.

Few people now recall that Major Powell's trip was in part subsidized by the state of Illinois and that he was receiving a salary from the state as the curator (1867-1872) of the Illinois Natural History Society Museum. In fact, Major Powell in 1867 was the first curator of the museum to receive salary and state funds for activities of the museum. The Natural History Society Museum in later years became the Illinois Natural History Survey and its collections form the nucleus of the Survey's extensive research collections.

This commemorative stamp will be available at your local post office after August 1.

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AUGUST 1969, NO. 82

Side Effects of Freeze Damage

Mentioning freeze damage in August is bound to raise some skeptical eyebrows. Recent research, however, indicates that freezing of woody plants may have side effects that continue through the growing season.

Low temperature or freeze damage on trees and shrubs is common in Illinois and other states of the Midwest due to the rapid and extensive drops in temperature that occur in late fall and early spring, when cold fronts move across the land from the north. A prolonged period of higher than normal temperatures during these periods may cause some species of plants to lose much of their cold-hardiness and become susceptible to injury by freezing.

In addition to the freeze damage that is evident at the time plants break dormancy, wilting and dying of new shoot growth may continue throughout the growing season resulting from stem tissue injury during the winter. In many cases these weakened or injured stems are attacked by insects and disease organisms that are not found on healthy, vigorous plants.

To gain some insight into freeze injury and its side effect on susceptibility of trees and shrubs to attack by disease organisms, Survey plant pathologist D. F. Schoeneweiss recently conducted a series of tests utilizing a specially constructed chamber in which the air temperature around plant stems could be lowered to well below zero without freezing the root systems. In this manner, weather conditions thought to be responsible for freeze damage in the field could be duplicated.

By lowering the temperature in the chamber to different levels, Dr. Schoeneweiss was able to produce typical freeze damage symptoms on many species of trees and shrubs. In addition, he was able to produce several degrees of injury, from complete stem kill to weakening of stem tissues without any visible signs of injury.

To find out if stems injured by freezing were more susceptible than uninjured stems to disease organisms, several species of trees were frozen in the chamber, then inoculated with fungi that commonly cause cankers on weakened trees. In most cases the frozen stems, even those which showed no visible signs of injury, became diseased, whereas

Fungus cankers on a thornless honeylocust stem weakened by freeze injury. (Photo by D. F. Schoeneweiss.)

stems that were not frozen remained healthy following inoculation. Another important fact was discovered when laboratory cultures made from the wood tissues of frozen stems revealed that the canker fungi often penetrated the stems far in advance of the visible canker symptoms. This could mean that the often recommended practice of pruning out cankers and dead stems may not be sufficient, at least in the case of plants affected by freeze damage.

What happens to an apparently healthy tree or shrub whose branches contain fungi that attack weakened tissues? When such a plant is placed under further stress, will cankers develop causing wilting and dieback or will the fungus die out in time in vigorous stems? These questions can only be answered through further investigation of the many factors involved in disease development. According to Dr. Schoeneweiss, results from experiments with frozen stems, combined with results of studies on the effect of other stress conditions, such as drought, on disease susceptibility, indicate that many of the current control recommendations for certain tree and shrub diseases may be outdated and should be revised for more effective disease control.

More Tips on Catching Bluegills

An article entitled "To Catch a Bluegill," which appeared in the June 1969 issue of the Survey *Reports,* presented some of the findings of Survey aquatic biologist D. F. Hansen concerning the depth distribution of bluegills at Lake Glendale in southern Illinois. In this article Dr. Hansen disclosed that availability of certain foods, rather than water temperature, determined where in the lake bluegills were present.

Another finding that might interest fishermen is that bluegills of all sizes occur in the shallow water but as a rule only those larger than 6 inches are found in the open water and usually it was the largest of these that were caught on trotlines on the very bottom in 19 or 20 feet of water.

A fisherman might wonder whether the depth distribution is the same all day and whether it changes at night. Trotline fishing was not the best technique for answering the second question since the bluegills did not bite well at night. From the small catches made at night it seems that the number of bluegills close to the bottom in deep water may be less at night than in daytime, but there is no mass movement of bluegills toward the surface waters after dark.

The indications are that some bluegills in deep water go from one depth to another during their feeding, but the vertical distribution of bluegills during different hours of daylight remains about the same in spite of up and down movements of individual fish.

Contrary to popular notions, there was no evidence of morning and evening feeding periods in the bluegills at Lake Glendale. Counts of the numbers of midge larvae, plankton, and other foods eaten in quantity showed that very little feeding was done by the bluegills before 8 a.m. Feeding begins at different times in different fish and is probably carried on over a period of at least eight hours of the day, probably ending between midafternoon and 9 or 10 p.m.

All the findings of Dr. Hansen, therefore, indicate that the best bluegill fishing in lakes during the hot summer months should be in deep water during the morning and early afternoon. Pardon me while I grab my tackle box and head for the nearest lake.

Don't Pitch Those Plants!

Collecting, identifying, and preserving living organisms is something that man has been doing for centuries in his desire to understand and master the environment in which he lives. The world is full of plant and animal life that is constantly changing, particularly under man's increasing influence. Unless organisms are collected and preserved, little knowledge can be gained on the changes that occur with time in plant and animal communities.

The collection and preservation of plant specimens is a tedious job requiring king-sized amounts of patience and dedication. Many worthwhile collections are made by

Examining a plant specimen in the herbarium of the Natural History Survey. Here are filed carefully mounted specimens of thousands of representative and rare plants from all parts of Illinois. (Photo by former Survey photographer William Clark.)

private individuals and represent a lifetime of work. In most cases, they could never be duplicated. To lose such collections through carelessness or lack of interest is tragic and wasteful. Fortunately, at least some of these private collections are eventually placed in permanent plant collections called herbaria. Most herbaria are maintained by institutions and are available to scientists and other interested parties.

During the past few years the Herbarium of the Survey, with Dr. R. A. Evers as curator, has received as gifts two sizable collections of vascular plants. One was the herbarium of the late Mr. Julian O. Neill, a retired high school biology teacher of East St. Louis, the other was the private herbarium of the Reverend Robert Brinker, O.F.M., of Quincy College.

The Neill collection contained over five thousand sheets of Illinois and Missouri plants, the bulk of which Mr. Neill had collected in St. Clair County, where he had actively botanized for more than twenty-five years. The Survey was indeed fortunate to receive this collection from the Neill estate. Among some of the unusual plants in the Neill herbarium is a rare quillwort collected near Caseyville. It could not be found there today.

The Brinker collection of more than 1,800 specimens is the result of Father Robert's interest in the plant life around him. Most of his collection came from Adams County, Illinois, and included the first Illinois records of the narrow-leaved green milkweed and the Kentucky viburnum.

The specimens contained in these collections are of scientific value and it is fortunate for Illinois botany that they have been placed in an institutional herbarium where they will be protected from damage and made available to interested scientists. Private plant collections often end in a trash fire or a city dump.

A suggestion is made here that persons who own similar collections make certain they will be preserved. If the owner no longer has use for the material, it is wise that he place them in an institutional herbarium without delay. If the owner wishes to make further study of the material during his lifetime, he may insure the proper preservation of his collection by stating his desire in his will. Valuable botanical material can thereby be saved from destruction.

Biodegradable Insecticides

The grim spectre of pollution is forcing man to place greater emphasis on the selection and use of chemicals that will not contaminate the environment. When persistent detergents threatened pollution of our waterways, they were replaced by biodegradable detergents that are broken down by living organisms. A similar approach is being taken with persistent insecticides.

Chlorinated hydrocarbons like DDT break down slowly in nature. The use of billions of pounds of these compounds in the past twenty years has resulted in their distribution throughout the world and their accumulation in food chain elements, which

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has become more apparent with the appearance of toxic levels in fish and birds.

Chlorinated hydrocarbons, however, are being replaced with organophosphates and carbamates which are highly biodegradable. It is essential to obtain as much information as possible about the effects of these newer insecticides on the environment to determine whether their continuous use may lead to undesirable results.

To gain some information about the fate of one of these insecticides in an aquatic environment, Survey Entomologist Keturah Reinbold traced the distribution and persistence of diazinon, an organophosphate insecticide, in a small volume of water in Allerton Lake. A metal cylinder two feet in diameter was placed in the edge of the lake with one end sunk a few inches into the bottom mud and the other end projecting above the water surface. Diazinon was added to the water confined in the cylinder.

Samples of water and mud were collected one hour later and analyzed for diazinon content. Organic matter was removed from the water and extracted separately. This procedure was repeated several times for nearly a year after treatment. The samples showed a sharp decline in the amount of the insecticide within the first six weeks. The greatest reduction occurred during the first week in water, during the second week in mud, and between four and six weeks in organic matter. Thereafter the decline was more gradual in water and organic matter. However, the residue level in the mud remained relatively constant.

After two months the amount of diazinon present was less than 5 percent and after eleven months only about 1 percent of the original was left. In contrast, chlorinated hydrocarbons such as DDT and dieldrin are reported to persist at the 90-95 percent level after a similar length of time.

According to Miss Reinbold, this investigation is just a start and much more information is needed to begin to understand the effects of these newer insecticides in the environment.

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SEPTEMBER 1969, NO. 83

New Angling

Management of Illinois warmwater ponds and lakes for fishing always has had the problem of overpopulation by sunfishes, chiefly bluegill. The result is a horde of stunted, useless sunfish that may even eliminate the bass on occasion by eating their eggs. In earlier times sunfish populations were kept down by predators, chiefly birds. Today control depends largely upon the presence of predaceous fish. For instance, the large flathead catfish are efficient predators, but unfortunately prefer the same size of sunfishes as do the fishermen. Other predatory fishes have been tried, but they either do not reproduce successfully under Illinois conditions, or they are poor sport fish and are themselves unwanted by anglers.

Various members of the pike or pickerel group of fishes are good predators. The northern pike, once quite common in the Illinois River, exists as self-sustaining populations only in a few glacial lakes in the extreme northern part of the state and do not reproduce in ponds. The muskelunge is an efficient predator, but has never been known to reproduce successfully within our state. The only pike common to Illinois is the grass pickerel, but it rarely attains lengths of 12 inches and is not an efficient predator.

The chain pickerel, a handsome fish occurring naturally in fresh waters along the Atlantic seaboard from New Brunswick to Florida and the Gulf states to Texas, was introduced into Ohio lakes, where is reproduced successfully. It seemed a logical choice for testing in Illinois. The first introduction was with 120 9- to 12-inch adults in three ponds near Dundee in Kane County in 1960. This experiment, although successful in that the chain pickerel did reproduce, had to be abandoned in 1962. A group of twenty-nine adult fish were moved to the new 160-acre McLean County lake in November 1962. Here they remained through 1967, but apparently disappeared in 1968. It is now believed that this pickerel decline was due to the appearance of an unusually large year class of largemouth bass in 1965 and that the pickerel were eliminated by predation by the bass.

In 1965 aquatic biologists D. Homer Buck and Charles F. Thoits of the Survey staff established the chain pickerel in a series of farm ponds in Marion County with various combinations with bluegill, largemouth and smallmouth bass, redear and green sunfish, and lake chubsuckers. From these studies it was found that the

Chain pickerel in hand. (Photo from color slide by Dr. George W. Bennett.)

chain pickerel is quite adaptable to our pond environment and reproduces successfully. It appears that the chain pickerel closely resembles the smallmouth bass in its inability to coexist with such native warm-water fishes as the largemouth bass, the bluegill, or the redear and green sunfishes.

Although the chain pickerel has not proven to be an efficient predator of sunfishes as hoped, it is a valuable sport fish when stocked in the right combination. This pickerel seems highly compatible with the smallmouth bass where these two are combined with the lake chubsucker. All three species appear capable of sustaining themselves when in the same pond, and the angler of smallmouth has an occasional bonus catch of pickerel for his creel. Studies of this combination are being enlarged and extended by Buck and his associates.

Insect Informants

For years naturalists have been intrigued by the fact that the tall-grass prairie-like openings scattered throughout the hardwood forests from Illinois to the Atlantic bear a striking resemblance to the tall-grass prairie of the eastern Great Plains. Both of these grass communities are dominated by bluestem grasses. The question has been: Did the prairie openings in the forests come from the prairie to the West or vice versa?

During studies of Illinois grass-feeding leafhoppers, Survey entomologist H. H. Ross noticed that the number of species in Illinois grass patches was much greater than the number in comparable Great Plains bluestem prairies. The inference from this was that the Great Plains leafhopper fauna was only a reduced version of that of the grass areas in the more eastern forests and, therefore, a later development. To obtain better information, Dr. Ross and his colleagues, T. L. Harris and T. A. Cooley, made collections of these insects every 50 miles along a transect from Illinois to Alaska and Illinois to Texas.

Preliminary analyses of these collections show that the Great Plains bluestem prairie leafhoppers are indeed a reduced version of the Illinois forest-glade leafhopper fauna. There is further evidence that certain of the species occurring both in the Great Plains and the forest-glade grasses originally evolved in the latter and later spread into the Great Plains. The inference is obvious. The grassy glades of the southeastern hardwood forests have been a hotbed of leafhopper evolution for long past ages. Of the great variety of leafhoppers arising there, relatively few can survive in the more rigorous Great Plains area with its greater extremes of temperature in both winter and summer, combined with its lesser rainfall and lower humidity.

These results indicate strongly that the forest-glade grass patches of Illinois and eastward have been stable ecological units for many millions of years longer than the presumably much younger Great Plains prairies.

Corn Pulling

The larvae of both the western and northern corn rootworms have seriously damaged cornfields in the northern half of Illinois over the past five years. These larvae damage corn plants by feeding on the roots. Small roots are eaten off, and larger roots are tunneled by the small larvae. The result is undersized plants with reduced yield and damaged plants, which often fall over, especially on windy days and after heavy rains. Because both species of rootworms have developed resistance to the chlorinated hydrocarbons, aldrin and heptachlor, Illinois farmers are now using the newer organic phosphate and carbamate insecticides.

In studying control methods for corn rootworms and evaluating the effectiveness of the different phosphate and carbamate insecticides used, a relatively simple and rapid method of estimating damage caused by the worms was needed. Some of the methods used include comparative counts of rootworm larvae in the treated and untreated plots, visual ratings of root systems for damage, and visual ratings of lodging of plants.

The pounds of pressure required to pull the root system of the corn plant from the soil is another method of estimating damage

Vertical corn puller at work with Mr. Kuhlman pointing to gauge. (Photo by Survey photographer Wilmer Zehr.)

to the roots by rootworms. This method was used by extension entomologists H. B. "Pete" Petty and Donald E. Kuhlman this year in four of sixteen corn rootworm demonstration plots in northern Illinois. The experiment was conducted in cooperation with county extension advisers. Cooperating in the project were Harold Brinkmeier, Carroll County; Stan Eden, Ogle County; Louis Engelbrecht, McHenry County; Jon Ellis, Bureau County; and Wallace Reynolds, Boone County.

The vertical-pull technique for evaluating corn root systems was developed by University of Nebraska entomologists several years ago. A simplified version of a "pull machine" was developed by D. C. Peters and G. J. Eiben, of Iowa. The apparatus used to pull the root system of the corn plant from the soil (see photo) includes a lever, fulcrum, recording dynamometer, and a Kelms Grip — a tool used by electricians for pulling cable through a conduit. Before the plants are pulled, they are cut about 16 inches above the ground, and the leaves are removed from the stub. One end of the electrician's grip is attached to the stub and the other to the recording dynamometer as the fulcrum and lever is positioned over the plant. Pressure is applied to the end of the lever, and total pounds of pull is indicated on the dynamometer. Plants with root systems severely damaged by rootworm feeding are removed from the soil with minimum force, often less than 100 pounds, while those without feeding damage may require 300 to 500 pounds of pull pressure.

The vertical-pull method has several advantages: It is fast, requires less man power, and removes human bias and judgment needed with the other techniques. Besides insect feeding, the principal factors that influence the pounds-pull are soil type and soil moisture, which are likely to vary in a given field. In the study just completed, Petty and Kuhlman found that an average of 148 pounds of vertical-pull pressure were needed to remove the plants from untreated plots in the four fields. In a comparison of fourteen insecticide treatments put on at planting time as a basal, the average pounds-pull ranged from 148 to 312 pounds.

The equipment used in the Illinois tests was designed and constructed by Robert Ellis, supervisory and professional scientist of the Illinois Natural History Survey. The dynamometer was provided by the Department of Agricultural Engineering.

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Busy Greenhouses

Plants are grown, then destroyed, insects reared and sprayed with insecticide, plants sprayed with fungicide, and so on, all in the interests of science in the Survey greenhouse. This greenhouse, under the supervision of James Sergent, is an important research facility in the fields of botany, plant pathology, and economic entomology for the study of plant diseases and insect pests. Not only does the greenhouse permit the scientists to grow plants and associated insects under controlled conditions, eliminating unwanted effects from insects or diseases, but it allows some plants to be grown the year round, thus making it possible to study a problem two or three generations of plants per year rather than in just one.

Gladiolus are being grown under fluorescent lights to intensify gladiolus virus research. Datura and tobacco plants are also being grown for use in virus studies. In another compartment various ornamental bedding plants are grown for various disease investigations. These include Ageratum, Ajuga, and Geranium. In another area plants are being grown to be used in studying fungicide persistence. These plants are sprayed with fungicide, then placed in a machine creating artificial rain in measured amounts, and then the ease or difficulty of the fungicide being washed off can be measured. This helps in determining the relative effectiveness of various fungicides being recommended for disease control of trees and shrubs.

Plants such as carnations, roses, chrysanthemums, orchids, azaleas, lantanas, soybeans, corn, and alfalfa are being grown in order to be able to rear various insect pests so that they can be studied by Survey entomologists. A few of the pests being studied are the alfalfa weevil, the corn leaf aphid, the black cutworm, and corn rootworms. Studies on the fate of pesticide residue in the aquatic environment are being made in growth chambers located in the greenhouse building.

Many other projects not mentioned here involve use of the greenhouse either for short periods or for long-term studies.

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OCTOBER 1969, NO. 84

Quail Management

The bobwhite quail is a popular upland game bird in Illinois. Like most wild species, quail populations rise and fall from year to year depending on many factors including the availability of suitable food, water, and shelter. Although putting out food patches and maintaining permanent cover plantings for quail are common conservation practices over much of the bird's range, these methods are relatively expensive and have not always been successful.

Studies on the ecology of quail populations being conducted by Survey wildlife specialists J. A. Ellis, W. R. Edwards, and K. P. Thomas clearly show that the bobwhite is a successional species. This means that quail are best suited to types of vegetation found in areas where new plant successions have been initiated following acts such as burning and logging, reduced grazing, or discontinuation of cultivation. Over much of southern Illinois, plant succession can be viewed as a series of stages characterized by weeds, grasses, brush, and forest in that order, with forest being the final or climax type of vegetation. Oaks in time replace ragweed and woodpeckers replace quail. Successional species such as quail cannot survive under extensive forest conditions and will thrive only in those habitats in which the weedy herbs and grasses of early secondary succession are well represented along with areas of brush and woodland representative of later stages of succession.

The adaptation of many plants and animals to these successional types of communities tells us that much of the world's land area has been repeatedly disturbed over long periods of geologic time by factors such as floods, drought, fire, and wind. In nature, periodic disturbance is normal, even essential in maintaining many of our most prized and productive wildlife habitats. While conservationists tend to place great emphasis on fire prevention, a rapidly growing number of wildlife scientists today are convinced that fire was a primary factor in the evolution of many major plant and animal associations. Periodic burning is considered highly influential in the development of the types of successional vegetation, such as grassland and savannah, in which the bobwhite evolved and thrived.

In experimental management programs conducted by Survey personnel in cooperation with the Illinois Department of Conservation, populations of bobwhites respond favorably to programs based on a combination of sharecropping and prescribed burning, and on burning alone. These programs provide a basis for management which is economical as well as ecologically more

Male (left) and female bobwhite quail. (Photo by Survey Photographer Wilmer Zehr.)

feasible than the common practice of basing management on a combination of annual food patches and permanent cover plantings.

Known the World Over

Research without published results is somewhat like having a shotgun without shells — it isn't very useful. Recognizing this, the Illinois legislature initiated specific appropriations to the State Laboratory of Natural History — the forerunner of the Illinois Natural History Survey — in 1879 for publishing results of biological studies. In that year the appropriation act specified for "publication of bulletins, the sum of two hundred and fifty dollars."

Today, as a result of that foresight, and with increasing appropriations over the intervening years, the published reports of the Survey are known, used, and respected the world over.

Illinois Natural History Survey scientists study the wealth of living resources of Illinois — insects, plants, fishes, and wildlife, and the lands and waters they inhabit. To determine the best means of controlling, protecting, or using them for the maximum economic and recreational benefits of all; the Survey's "office of publications and public relations" exists to help disseminate the results of this research to agriculturists, sportsmen, industries, scientists, and all interested citizens of the state.

In addition to the thousands of letters, telephone calls, and visits to the Survey from residents of Illinois each year, many more requests for information are received from other countries as well as throughout the United States. Also, the Survey maintains an exchange of publications on biological subjects with more than six hundred scientific societies and institutions all over the world.

In extending the usefulness of research findings far beyond meeting rooms and personal contacts between the researchers and individuals, broad distribution of the Survey's information is accomplished through varied channels. Among them are the Survey's own publications — technical bulletins, semitechnical reports, and popular and practical "how-to-do-it" circulars — and numerous articles in technical journals plus news releases for newspapers, radio stations, and other mass media outlets.

To assist the research scientists and handle this information job, the Survey maintains an editorial and graphic arts staff including two editors, a technical photographer, technical illustrator, and a newswriter-secretary. The office also has charge of the central files containing more than fifteen thousand photographs that are useful in illustrating reports on insects, wildlife, plants, fishes, and other aspects of biological research. Through the years at the Survey, exactness of research and quality of the published reports have been given precedence over quantity of research and speed of publication, and as a result many of its reports stand as landmarks in biological literature.

Anyone interested in the Survey's wide variety of available publications can request a free copy of this listing, *Publications of the Illinois Natural History Survey,* by writing to Dr. George Sprugel, Jr., Chief, Illinois Natural History Survey, Natural Resources Building, Urbana, Illinois 61801.

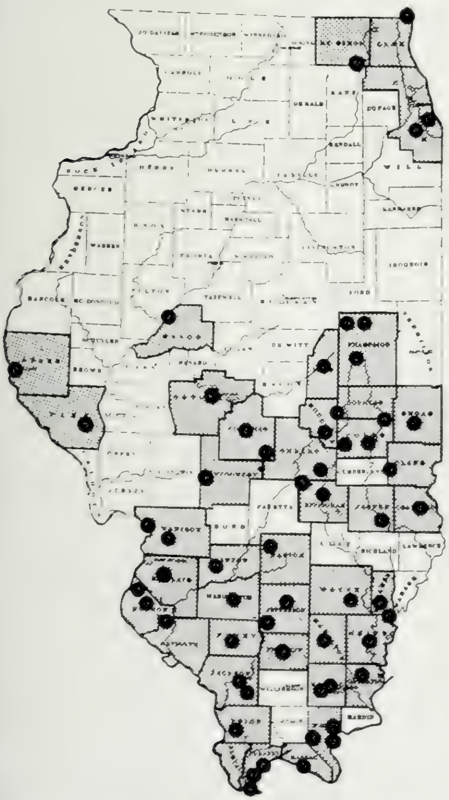
Spider Bites and the Brown Recluse

Since it was first discovered in Illinois in 1957, the brown recluse spider has received increasing publicity in the news media. It is now considered a public health problem in Illinois and many other states. This spider is a southern species which cannot survive the winter outdoors in Illinois, consequently it prefers to live in or near houses and buildings. It bites only when it is disturbed or feels threatened and has a habit of hiding in dark places, such as bedding and clothing and in storage containers in closets, attics, and basements. These habits often bring the brown recluse in contact with humans.

Although reports of the brown recluse in Illinois were rare before 1966, Survey insect taxonomist J. D. Unzicker has now identified brown recluse spiders from 42 of Illinois' 102 counties (see map). Many of these county records are based on only one or two specimens taken in houses. The

spider occurs in all states bordering Illinois except Iowa, but it is most abundant in the southern part of the country.

During the past year, Dr. Unzicker has received reports of bites producing necrotic lesions that are painful and slow to heal. These bites have been attributed to the brown recluse spider. Reports have come from widely scattered areas in the state, and in several instances the bites have resulted in deaths. Unfortunately, these bites are mostly of an unknown origin, and are attributed to the brown recluse on the basis of the resulting wound. This spider is dangerous but care should be exercised in correctly identifying the brown recluse as the culprit in cases of bites. Little or nothing is known about the bites of many common and more abundant "household spiders," and it is possible that one or more species may be responsible for bites similar to those of the brown recluse.



Known distribution of the brown recluse spider in Illinois. Each dot represents a location from which one or more spiders were collected and identified.

When spider bites occur, the spider responsible should be captured if possible and sent to the Illinois Natural History Survey for proper identification. Much information of this type is needed before control measures for dangerous spiders can be worked out and spider bite treatments developed. If care is not used in correctly identifying the spider responsible for a bite, other potentially dangerous spiders may go undetected.

Zapped With Zinc?

The toxicity of zinc and other heavy metals to many organisms has been known for some time. Insects are no exception. Why zinc is toxic to insects and how it affects them, however, is still not well understood.

Recently Survey entomologist D. K. Sell and his associates observed that zinc in ionic form was toxic to larvae of the tobacco budworm. It appeared that zinc in ionic form above a certain concentration is repellent to these larvae but below this level actual toxicity occurs. They also found that zinc incorporated into a certain chemical compound known as a chelate was very toxic to budworm larvae, whereas the same amount of zinc in a different chelate was much less toxic. Results such as these may aid scientists searching for the most effective form of zinc which might some day be used to control certain insects.

In an attempt to find out how zinc affects insects, Mr. Sell and his group are working in several areas of research. One of these is the effect of zinc on insect feeding. Tobacco budworm larvae raised on food which contained a small amount of added zinc grew much more slowly than larvae reared on food containing only trace amounts of zinc. The larvae usually die after only a few days on the zinc enriched diet without completing their life cycle. One reason for this early death could be reduced food intake, a possibility that is now being investigated.

Zinc is a potent inhibitor of respiratory enzymes in some animals. Budworm larvae fed diets containing added zinc for twenty-four to forty-eight hours consumed less oxygen than those fed diets with only trace

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amounts of zinc. This may indicate that zinc affects insects in the same manner as it affects higher vertebrate animals. More information is needed to answer this question.

One way to find out how zinc affects organisms is to trace the movement of radioactive zinc particles throughout an organism using very sensitive detecting equipment. The absorption and distribution of radioactive zinc in tobacco budworm larvae is still another phase of research under way at the present time.

Hopefully, results of all this research on zinc may help scientists to understand how heavy metals and metal chelates affect insects. Whether zinc or other metals can be used for insect control remains to be seen.

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NOVEMBER 1969, NO. 8[illegible]

Nightmares and Oddballs

About three years ago Survey entomologist Clarence E. White began rearing an eastern strain and a western strain of the alfalfa weevil. The western strain was first discovered in Utah in 1904, from where it spread rather slowly so that by 1968 it was known in fourteen western states ranging in the East through the center of the Dakotas, Nebraska, and Kansas. The eastern strain was first found in New Jersey in 1952, from where it spread very rapidly. By 1968 the eastern strain was present in thirty-two states from Maine to Georgia and west into southeastern Iowa, southeastern Kansas, and northeastern Oklahoma. The eastern strain of the weevil is the most destructive pest ever to hit alfalfa fields in the United States. In many areas alfalfa stands are completely killed unless two or three chemical treatments are applied each year to control the destructive larvae of this weevil.

Rearing of these two strains of weevils began in the laboratory of the Survey when it became obvious that they would meet under natural conditions somewhere in the Midwest. The question posed by the entomologists was, "Will they cross-mate to produce a new strain showing hybrid vigor and more destructive than either parental strain?"

The thought of a strain of alfalfa weevil showing hybrid vigor was enough to give nightmares to anyone familiar with the eastern strain of this weevil and the damage it causes. However, the nightmares are becoming more manageable as laboratory studies indicate that no hybrid vigor will occur from cross-matings of the two strains. Certain crosses produce eggs with less than 1 percent hatchability, others produce adults with very abnormal sex ratios, but there has been no visible evidence of larger or more vigorous individuals among the progeny.

This study has produced some interesting genetic oddballs such as adult weevils which cannot fly due to deformed wings and adults with certain ventral segments deformed or missing. Perhaps the oddest specimens have been found by Jane Ashley, sharp-eyed laboratory assistant, who has spotted a few tiny, newly-hatched larvae each with one well-developed head and thorax and two well-developed abdomens. These "Siamese twins" have all died before reaching the second instar.

Roadside Pheasant Farming

A unique undertaking is the seeding and management of roadside vegetation for nesting pheasants being tried experimentally in Ford County by Survey wildlife specialist G. Blair Joselyn in cooperation with the

Alfalfa weevil larva with two abdomens. (Photo by Survey photographer Wilmer Zehr.)

Illinois Department of Conservation. This experiment is unique because it attempts to establish permanent nesting cover in an intensively farmed, cash-grain crop area — even if on a limited scale — and because it represents a scheme based upon research data which demonstrates that pheasants will benefit from the development.

Research to determine the management potential of establishing habitats (grasses and legumes) for nesting pheasants in east-central Illinois was initiated in 1962. During the six-year period from 1963 through 1968, the 2.9 nests per acre on unmowed roadside plots seeded to a grass-legume mixture exceeded the 2.0 nests per acre on unmowed, unseeded roadside plots (managed control plots), and the 1.3 nests per acre on unseeded plots in which mowing was left to the farmers' discretion — unmanaged control plots. During these six years, seeded roadsides also had greater densities of nests per acre than any of seven other cover types (hay, wheat, oats, and so on) in the study area. Also, the hatch of pheasant nests on seeded roadsides was significantly greater than in the control plots on roadsides and in most of the other cover type plots.

Seeding of roadsides is now being attempted in order to answer practical questions regarding such problems as: the acceptance of seedings by farm operators and their willingness to delay mowing until after hatch time; the time required for, and the problems of, establishing seedlings from a standpoint of equipment operation; the cost of establishment and maintenance of seedlings; the effects of roadside seedings on pheasant population levels.

During 1967 a 16-square-mile area between Sibley and Melvin in Ford County was designated for trial seeding. The area was studied during 1967 for feasibility of seeding, to estimate pheasant population levels and to study normal maintenance procedures of roadsides. Sixty-one of the sixty-five farmers contacted agreed to take part in the program. These farm operators agreed to mow their roadsides closely in early August of 1968 to facilitate seeding and to delay mowing in 1969 and subsequent years until after most pheasants hatched successfully.

In 1968 fertilizer, lime, and defoliates were applied, the roadsides were mowed, seeded with the Howard Rotevator Company's Rotaseeder, and rolled. Smooth bromegrass and vernal alfalfa were the cover crops seeded. Total costs amounted to $10,124 or $139 per mile of roadside ($68 per acre). Amortized over a ten-year period, these costs appear more reasonable. It is expected that these costs could be reduced to half this amount in a large-scale operation where some refinements such as fertilizing could be omitted and supervisory expenses would be much less.

The effect on pheasant populations will be assessed in 1969 and future years using the same techniques as were used in the Sibley study area in the 1963-68 studies. The success of this venture could mean greatly increased pheasant populations in areas where the very intensity of cultivation practices tends to lower the population levels of these game birds.

Pot Thrips

Marijuana or pot is a common weed in northern Illinois of much concern to law enforcement and narcotics agents. It is also the subject of intensive biological studies by botanists at the University of Illinois and by entomologists at the Survey. The botanists are studying the plant's ecology and dispersal, whereas the entomologists are interested in insect pests of marijuana as a possible means of natural control of the weed. Taxonomist Lewis J. Stannard, together with research assistants Gerald DeWitt and John Marlin, have been collecting insects from marijuana throughout the state during the summer of 1969. They have also been bringing fresh cuttings of marijuana into the laboratory to search for smaller insects which cannot be collected readily in the field.

By washing marijuana leaves in detergent over filter paper and examining the residue under a microscope (a technique just perfected by entomologist Thomas Wilson during his studies of thrips injurious to soybeans), a thrips new to Illinois and to the United States was discovered. This minute (one-twelfth inch) insect known to science by the impressive name

of *Oxythrips cannabensis* was previously known to occur in Hungary, Russia, and Czechoslovakia. The marijuana thrips lives only on marijuana and to date has been taken in fourteen counties in Illinois, all in the northern half of the state. Marijuana had been searched for thrips in previous years but those found were mostly common flower thrips and have been reported in the Survey Bulletin on the *Thrips of Illinois* by Dr. Stannard.

Because of the public furor over marijuana and the collecting of marijuana in Illinois, our entomologists were provided with letters of explanation on why fresh cuttings of pot were being taken back to the laboratory. Thus far, none of the entomologists (or botanists) have ended up incarcerated.

Catfish-Shiner

Growers of fish are constantly seeking to increase production, just as growers of other crops are concerned with increasing yields. From Illinois southward the two most important fishes cultured in fresh water are the channel catfish, as a food and sport fish, and the golden shiner, as a bait minnow. Annual sales of each of these are in the millions of dollars. While each fish has a specialized culture, there is interest in the degree to which the two may be combined in culture. The U. S. Bureau of Commercial Fisheries has given Survey biologists D. Homer Buck and Richard J. Baur financial encouragement in a limited study of the interrelationships of the channel catfish and the golden shiner.

Preliminary studies conducted in early 1968 consisted of growing the fishes indoors in 10-foot diameter plastic pools. In one pool the two kinds of fishes were separated by a nylon net, and in another pool two mixed groups of these fishes occupied each side of the area separated again by a nylon net. Total area and volumes of the pools were similar, total numbers of fish and initial weights were equal, and each pool received the same total amount of food. After 134 days the fishes in each of the groupings were removed and weighed. When unmixed the crop of fishes was equivalent to 2,555 lbs/acre (1,942 shiners and 613 catfish), and when mixed 2,708 lbs/acre (1,838 shiners and 871 catfish). Growth of the catfish was limited by the relatively cool water, whereas that of the shiners was impressive. The greater total production when the two species were mixed indicated a high degree of compatibility.

Marijuana thrips. (Photo by Thomas Wilson, retouched by Survey photographer Wilmer Zehr.)

These experiments were expanded to outdoor pools during the summers of 1968 and 1969. All pools received meticulously standardized soil substrates. Some pools were divided into halves with nylon screens permitting a concentration or separation of the species as desired but, when separated, a sharing of the same water. Catfish, shiners, and tilapias were used alone and in various combinations at two density levels. No antagonistic behavior was observed between species and predation was not a factor, although this may be because the catfish were small. All three species were stimulated to faster and more vigorous feeding when associated with other

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species than alone. Shiner production was greater when mixed with catfish than when separated and the presence of tilapia and/or shiners did not cause significant loss in catfish production.

In 1969 shiners and catfish were again tested in twenty-nine outdoor pools containing soil substrates and nylon screen dividers. The densities of 1968 were doubled, bringing maximum densities to about 18,000 catfish and 100,000 shiners per acre. Although differences in the results were slight, the highest individual production by either species occurred when both were sharing a pool in direct physical association; these poundages were higher than when the same number of either species was maintained alone in the same column of water.

Two additional series of experiments with catfish and shiners were conducted in 1969. In the first series, dividing screens provided four differing degrees of association between the species. Here no significant difference was found between the production of shiners when alone and when mixed with catfish. However, channel cat production was slightly higher when the two species were mixed. In the second series, the water was circulated back and forth between paired pools in such a way as to minimize differences in turbidity, temperature, algal content, and so on. The results showed no differences in production when the species were mixed or alone.

The evidence from these trials seems to suggest that the production of neither catfish nor golden shiners is lower in the presence of the other and that a greater production per unit of water might be achieved through a combined culture of the two species. The results certainly indicate that testing under actual pond conditions would be worthwhile.

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DECEMBER 1969, NO. 86

Eskimo Geese

The Canada goose, that magnificent bird that raises the pulse of Illinois hunters every fall, has become a part of the art and literature of man throughout its natural range. Migrating south in the fall and north again in the spring, the typical V-shaped flights of honkers have interested men for centuries. The part the goose plays in the life of the Eskimos who inhabit the far north breeding grounds is a fascinating story in itself.

The breeding grounds of perhaps 95 percent of the Canada geese that winter in southern Illinois lie in "The Great Muskeg," that vast tract of wilderness in northern Ontario adjacent to Hudson and James bays. When a near disastrous decline of this population in the 1940's resulted from hunting, Survey wildlife specialist H. C. Hanson made a flyway-wide study of Canada geese. A publication of Dr. Hanson's findings furnished the background for intensified refuge development and management programs that have resulted in a tenfold increase in the Canada goose population in recent years.

Each year a number of Canada geese banded in southern Illinois are killed by Eskimos in northern Quebec on or near the east coast of Hudson Bay, particularly inland from the ports of Harrison and Povungnituk. An early study of these kills and the associated geese populations indicated that the kills were comprised mainly of late-arriving, nonbreeding geese that migrated into these areas from the bay areas for the purpose of molting. Recovery of banded geese clearly showed that this was a summer kill, made by the Eskimo, who of necessity turned inland for food when seals became difficult to hunt along the coast with the advent of open water.

A drawing by one of the finest untutored Eskimo artists, Pauloosie Sivuak of Povungnituk, Quebec, depicting the annual "run-down" of molting Canada geese. (Photo by Survey photographer Wilmer Zehr.)

At such times the Eskimo runs down the molting geese on foot. In contrast, the kill of Canada geese along the east coast of James Bay is made in spring and fall when the geese are migrating.

On a recent trip to the bay areas, Dr. Hanson was able to obtain a collection of scientific specimens to aid in his work and, in addition, obtained some excellent examples of Eskimo art which reflected the importance of the Canada goose in Eskimo life and culture. The drawing reproduced here depicts, with great taste and skill, an Eskimo engaged in the annual "run-down" of molting Canada geese.

The giant Canada goose, long believed extinct, was rediscovered by Dr. Hanson at Rochester, Minnesota, in 1962. As a consequence, it soon became apparent that paintings of Canada geese from the great plains where the artists hunted and painted years ago were indeed representative of the giant Canada goose and not merely artists' interpretations..

Although art and literature are seldom thought of as being of value in scientific research, in many cases information difficult or impossible to obtain elsewhere may be a part of the culture and lore of a people.

War Against Mites

Although excellent control of insects and diseases of apple and peach trees has been achieved with chemical pesticides, growers have had great difficulty with tiny spider mites that feed on the foliage and fruit. These animals are hard to see but have explosive reproduction potential with tremendous populations building up over a relatively short period of time. In addition, mites become resistant to chemical pesticides very quickly.

Unsprayed apple and peach trees seldom show much mite damage due to the presence of predators that feed on the mites. Unfortunately, fruit production is uneconomical unless trees are sprayed with insecticides to control insects that attack the fruit. But since these insecticides also kill mite predators the result is quite a problem in mite control.

There is much interest at present in using biological agents in pest control, but little can be done until some of the major fruit destroyers are removed from the scene by new techniques being developed. However, another possibility became evident when organophosphate insecticides began to replace older, more persistent chemicals in orchard pest control. It seemed use could be made of resistance that develops in predator mite populations to actually control the plant-feeding mite pests. Since plant-feeding mites become resistant to most organophosphates in less than two seasons, predator mites could also be expected to become resistant.

In 1966, Survey entomologist R. H. Meyer found the first case of predator mite resistance to the most widely used organophosphate Guthion. To find out what effect other pesticides might have on these resistant mites, many commonly used pesticides were tested on populations of predator mites in 1968, in a block of trees that were being sprayed regularly with both Guthion and malathion. Through information gained in this test, suggestions were made to commercial fruit growers as to how they might adjust their spray schedules to make the best use of the predator mites.

During the 1969 season, mite populations were sampled several times in orchards throughout the state to watch the progress of these attempts at integrated mite control and to collect specimens of the predator mites for identification. In most of the orchards sampled, an application of plant spray oil was made to kill European red mite eggs before the predator mites emerged from hiberation. This measure was sufficient in some orchards; in others it was necessary to apply a miticide to suppress the population of plant-feeding mites until predator mites could build up sufficient numbers to control them. Following these procedures, most orchards had mites controlled for the rest of the season.

According to Dr. Meyer, we need to know more about the effect of all pesticides on the predator mites and more about other factors which influence these animals. In addition, we need to know how to quickly develop resistance in predator mites when a new pesticide is introduced. In this way

predator mites can be used along with pesticides in an integrated mite control program.

Corn Rootworm and Rot Team Up

In recent years cornfields in Illinois have been increasingly invaded by the small larvae of two species of insects — the northern corn rootworm and the western corn rootworm. The adult insects are beetles which lay their eggs in the soil during the fall. Just about the time the corn plants have gotten a good start in early June of the following year, the eggs which have survived the winter hatch. Those larvae that are not killed by insecticides attack the corn roots and feed voraciously. The damage they cause is serious enough in itself, but in addition the wounds made by the larvae in entering the roots provide open doors for the entrance of root rot organisms which multiply rapidly in the root tissues.

In investigating this problem, Survey entomologist W. L. Howe along with University of Illinois plant pathologist M. P. Britton examined affected roots carefully and found that a serious rot fungus Fusarium attacked the older damaged tissues and greatly extended the initial damage caused by the rootworm. Although the rootworm larvae work their way up the root ahead of the rot fungus, they found that if conditions in the soil are favorable for rot, the entire root may become a slimy mass of little use to the corn plant.

Fortunately, the corn plant has the ability to fight back. The portions of the hard inner core of roots nearer to the plant give rise to secondary roots not normally produced in undamaged plants. These grow rapidly, and, in many cases if the plant was not blown over when the roots were first weakened, the plants may partially recover by the end of the season. Nevertheless, considerable damage usually occurs in fields heavily infested with corn rootworms.

Since it was well known that insecticides do not control 100 percent of the worms, Dr. Howe and Dr. Britton tried applications of insecticide-fungicide combinations in an effort to control both rootworms and the damaging Fusarium simultaneously. Although further research is needed to completely assess their value, some of these combinations are showing promise in reducing the damage caused by the rootworm root rot complex.

Official seal of the ISTC which is authorized for use by its members.

Urbana New Home for Shade Tree Group

The International Shade Tree Conference, well known to professionals in the field throughout the world, recently moved its headquarters to Lincoln Square in Urbana after being located in Columbus, Ohio, for over thirty years. In conjunction with the move and as a result of his active participation in Conference affairs, Survey plant pathologist E. B. Himelick was appointed executive director of the international organization, replacing Dr. L. C. Chadwick, of Ohio. Dr. Himelick is presently serving as president of the Midwestern Region of the ISTC, which covers a twelve-state area.

E. C. Bundy, former owner of Bundy Horticultural Service, Urbana, was appointed full-time executive secretary with offices in Lincoln Square.

Now forty-five years old, the forerunner of the ISTC organization began with a group of forty individuals engaged in some phase of shade tree work or research. Today the Conference has grown to nearly two thousand members in six U. S. regions and a Canadian region. There are foreign members in Australia, Denmark, England,

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Puerto Rico, and West Germany. The membership is composed of commercial, municipal, and utility arborists and academic personnel concerned with shade tree maintenance and research. College students studying arboriculture or related fields may join the Conference as can members of garden clubs or city beautification organizations. This diversity of the group's membership enables component groups and individuals to receive the benefit of advice from professionals in the field.

Discussing the purposes of the ISTC, Dr. Himelick states that the Conference strives to improve the practice of tree preservation and to stimulate a greater interest in the planting and care of shade and ornamental trees. The organization also tries to cooperate in the conservation of trees and beautification of the countryside.

Another facet of the Conference's work involves initiation and promotion of scientific investigations into the various problems encountered in the practice of arboriculture. Research projects sponsored by the ISTC include studies on the effects of transplanting on trees, species response to poor soil aeration, control of Dutch elm disease, chemical analysis of leaf tissues as an index to fertilizer requirements of trees, prevention of fruiting of shade trees, and factors which influence trunk development of young trees.

The ISTC prepares a monthly publication, *Arborist's News,* which is distributed to members and accredited libraries. In addition, the Conference publishes proceedings of its annual meetings, special committee reports, and findings of research projects it sponsors. The latter two publications are available to the public at a nominal cost.

Illinois is fortunate to serve as host for this distinguished organization. The move to this state reflects the stature and influence of Illinois scientists and other personnel in the field of tree research.

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JANUARY 1970, NO. [illegible]

Bass-bluegill Ecology

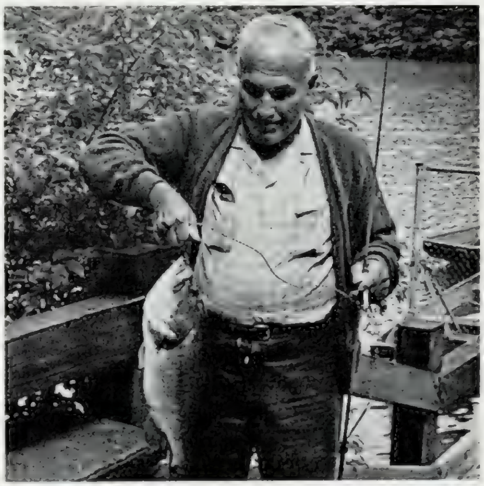
The history of fishery management research projects at Ridge Lake between 1941 and 1963 has recently appeared as Article 1 of Volume 30 of the Illinois Natural History Bulletin. This publication entitled *Largemouth Bass and Other Fishes in Ridge Lake, Illinois, 1941–1963,* by G. W. Bennett, H. W. Adkins, and W. F. Childers, is obtainable without cost by writing to the Illinois Natural History Survey, Natural Resources Building, Urbana, Illinois 61801.

Fishery studies at Ridge Lake, a 17-acre artificial impoundment in Fox Ridge State Park near Charleston, have included a complete creel census each year when the lake was open to public fishing during June, July, and August, nine fish censuses during which the lake was completely drained, the fish removed, enumerated, and weighed, and selected kinds and numbers returned after the census had been completed. During the first ten years of operation a census was taken every two years. Only bass of catchable sizes and a few hundred bluegills were put back into the partly refilled lake basin after each census. Small bass and small bluegills were used for stocking new or renovated waters or were discarded. Under this system of biennial culling of small bass and small bluegills, the lake produced larger catches of bass of larger sizes at higher rates of catch per hour than in any later period.

From March 1951, to March 1956, Ridge Lake was subjected to an annual September water level drawdown which reduced the lake to about 5 acres from its original area of 17. This reduction in lake area and volume concentrated the fish and greatly changed their predator-prey relationships. During and immediately after the drawdown, the smaller bluegills were the most vulnerable of all of the fishes to predation. These drawdowns, with the severe losses of small bluegills, were always followed at the next spawning season by increased survival of small bass.

Under this system of bluegill population control, total bluegill numbers in the lake were reduced from eighty or ninety thousand to fifteen to twenty thousand, and those that survived grew rapidly to large sizes. However, a larger number of small bass was associated with a smaller number of large bass in the catch.

The period of stable water levels, which began with the fish growing season of 1956 and extended to the end of the growing



A fisherman cooperator with a nice largemouth bass. This fish was marked when small by clipping the left pectoral fin and recaptured several times in draining censuses before it was caught. (Photo by G. W. Bennett.)

season of 1959, was favorable to successful spawning and high survival of bluegill fry, allowing a buildup of excessive numbers of small bluegills and a gradual reduction in the numbers of largemouth bass. Fishermen caught many bluegills, but they were small. Bass attempts at spawning were mostly unsuccessful.

Bluegill x warmouth and red-ear x warmouth hybrids that were stocked in Ridge Lake in 1960 and studied 1960–63 were so unwary and aggressive that most were caught before they had time to grow to useful sizes.

During the period 1941 to 1963, fishermen and biologists removed an excess of 29,700 largemouth bass and 390,000 bluegills from Ridge Lake. These all originated from 435 bass and 129 bluegills stocked in 1941 and 1944, respectively. On this basis, bluegills appear to be more than 10 times as efficient as bass in the Ridge Lake habitat. The lake will support about 50 pounds of bass per acre as a maximum and around 200 pounds per acre of bluegills and other fishes.

There was no relationship or a negative relationship between the number of bass spawners and the estimated numbers of bass fry produced in any given spawning season. There was also a strong negative relationship between numbers of small yearling bluegills per acre and the estimated numbers of bass fry that survived to the schooling stage.

New Mite, New Site

Many kinds of mites are associated with insects, as commensals, as parasites, or for transportation. Very few live internally in insects, namely in the breathing tubes or trachea. Survey scientists have discovered a new, ultratiny mite, living in the body cavity of the slender seed-corn beetle, attached to the oviduct. To the benefit of the farmer, this new mite prevents or nearly prevents reproduction by the destructive seed-corn beetle, thus effecting biological control.

During a recent routine check of the potential egg production of the slender seed-corn beetle, Indian student, S. M. Vaishampayan, dissected out a number of sacs attached to the beetle's oviducts. Further dissection under the microscope revealed that these sacs were filled with mother mites, eggs, and young. About a third of the one hundred beetles examined were infested by these mites. Of those infested, 94 percent had degenerated ovaries and no beetle eggs were being produced. Obviously the tiny mites were helping keep down the populations of the beetle, which often causes economic damage to newly planted corn.

According to Survey acarologist L. J. Stannard, the mite is a member of the family Podapolipidae, and represents a new genus and species heretofore not known to science. It is highly evolved, being so specialized that it becomes mature and produces eggs while retaining the six-legged larval form, a phenomenon called neotony. Most other mites develop eight legs before becoming mature. The mother mite swells with eggs and deposits them within her sac. The eggs produce a six-legged form with exceptionally long anal setae. Later this first stage transforms into a mother form — still with six legs — and the life cycle can begin again. Unless swollen with eggs, these mites are so small that dozens of them could fit on the head of a pin.

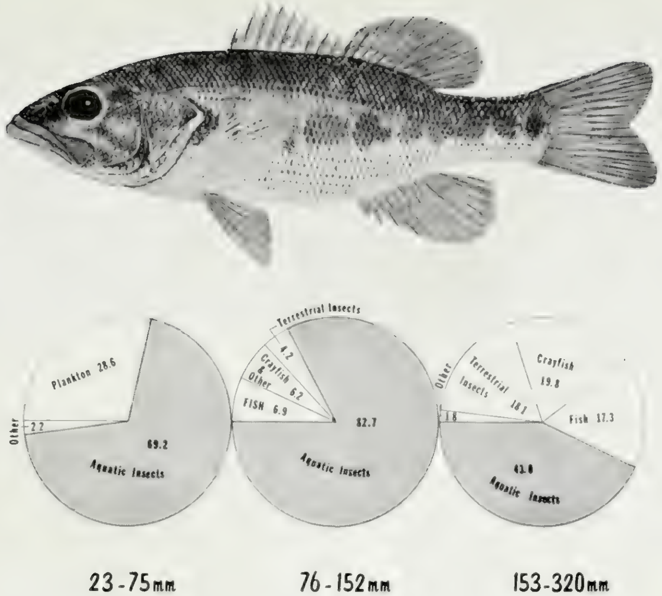
Males of this mite have not been found as yet. The males may be rare, or they may die very quickly after mating. However, this mite seems to need no males to reproduce. That is, it is a parthenogenetic species.

Menu for Spotted Bass

Basic research seldom produces spectacular and glamorous results, but it provides the solid building blocks necessary for contributions to our scientific knowledge. Basic research is essential because a scientist cannot base a premise or a recommendation upon guess work. Instead he must use factual information that is made available to him through his own research or the basic studies of other scientists.

An illustration of research of this kind is provided by a recently published article entitled "The Food of Spotted Bass in Streams of the Wabash River Drainage," by Survey ichthyologists P. W. Smith and

Adult spotted bass (from a water color by Mrs. Alice Ann Prickett) and principal foods of three size classes of the species expressed in percents of total food.



L. M. Page, who studied the food habits of bass of various sizes from early spring until late fall in conjunction with a life-history study of another fish.

While it is generally assumed that bass feed on other fish, such an assumption is inadequate and unsatisfactory, for in Illinois there are three different kinds of basses: spotted or Kentucky, smallmouth, and largemouth. Since they live in different habitats, they will not be feeding on the same types of organisms. Even within one kind, food habits will vary with the size of the bass, seasonal availability of prey, and type of environment.

In fact, authors Smith and Page found that spotted bass in streams of the Wabash River valley utilize aquatic insects as food much more than they do fish. They found that small bass, as anticipated, supplement their diet with planktonic organisms and that large bass feed on crayfish, fish, and terrestrial insects. But aquatic insects comprise the main food for spotted bass of all sizes. In artificial lakes, however, the spotted bass is reported to feed mostly on other fish.

The information gained by this basic investigation adds to our knowledge of ichthyology — the study of fishes — and is of potential usefulness to fishery biologists because it notes seasonal differences in feeding habits between small and large fish, and it contains a breakdown of the different food organisms utilized by the spotted bass in a stream environment.

Single copies of this five-page publication are available upon request to the Chief of the Survey.

Insect-toxin Baselines

Several years ago when the northern corn rootworm became resistant to the insecticides then in use, entomologists had no records of how little or how much of the several insecticides was originally required to kill this pest. In other words, no data were available with which to compare the resistant strain in order to pinpoint how resistant the insect had become. At the time corn rootworm resistance to insecticides was first noticed (1963) a program was developed so that we now have records of rootworm response to many insecticides.

Survey entomologist Ralph Sechriest has similar programs monitoring the insecticide responses of several other economic pests such as the western corn rootworm, the slender seed-corn beetle, the striped seed-corn beetle, the true armyworm, the black cutworm, the dusky sap beetle, and the fall armyworm. With luck this program can be expanded to other insects including many beneficial species such as the cabbage aphid parasite on which preliminary data has already been obtained. This information has not previously been available for Illinois insects.

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These tests can take several forms and might utilize three or four different techniques. The one used most by our laboratory is a "media cup test." The surface of the artificial food (media) in a medicine cup is treated with a known amount of insecticide and the larvae (caterpillars) are allowed to feed on the treated food for four days. Each day the number of dead larvae are counted and recorded. At the end of the experiment, the percent which were killed is determined and these figures are plotted on special graph paper (log probit). We then calculate from the line on the graph the amount of insecticide necessary to theoretically kill 50 percent of the population or LC_{50}. A similar technique is used with beetles. One very small drop of insecticide is placed on each individual beetle, and then the mortalities are calculated. In each test, 150 insects may be used.

These tests help us in two ways. We can determine right now which insecticide is most toxic to the insect and will probably be of most value when used in field experiments. In the future the recommended insecticides can be periodically tested in the same manner and the results compared. Hopefully we can be alerted if another resistance problem is developing.

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Pesticides and Fish Yields

The effects of pesticides on the environment have received much publicity lately but what are the facts? Do the persistent pesticides such as the chlorinated hydrocarbons DDT and dieldrin which are used in great quantities in agriculture actually harm wildlife? Is fish reproduction affected when these materials run off farm fields into ponds and streams? Such questions can only be answered through scientific research.

In 1969, a Survey pollution investigation team composed of aquatic biologist W. F. Childers and entomologists W. N. Bruce, Keturah Reinbold, and Jean Wilson measured the concentration of chlorinated hydrocarbons in the water, mud, and fish in a 1 acre farm pond. The pond contained largemouth and smallmouth bass, white crappies, bluegills, and longear sunfishes. The water shed of this pond has been treated each year for the past seven years with chlorinated hydrocarbon insecticides.

This investigation showed that the pond mud contained relatively high amounts of these insecticides, whereas the pond water contained only one–ten thousandth the concentrations found in the pond mud. The fish in the pond accumulated three thousand times the concentrations found in the water.

DDT and dieldrin are quite insoluble in water but very soluble in fatty material. The eggs of sunfishes contain large quantities of fatty material which serves as food for the developing embryo. When the female fish is about ready to spawn, the eggs take on large quantities of oil and it was discovered that the mature eggs contained about ten times the concentration of the insecticides found in the rest of the fish tissues. Later laboratory experiments indicated that the young produced from these eggs suffered up to 90 percent mortality before they reached the free-swimming stage.

The fish population in this study was sampled at intervals during the spring and summer of 1969. At the end of the summer, large samples of fishes were held alive in a special holding basin and those remaining in the pond were killed with rotenone to allow the biologists to make a complete census of the fishes. The census data indicated that there had been very little successful reproduction in this pond during the past three years. No young largemouth bass, smallmouth bass, or white crappies were produced in 1969 and young bluegills were not produced until August.

Bluegills collected from a farm pond polluted with insecticides. All bluegills and crappie in this pond were less than 6 inches long. (Photo by G. W. Bennett.)

Largemouth and smallmouth bass and crappies spawn for a short period in late May and early June whereas bluegills spawn several times throughout the summer. Since these insecticides are concentrated in the eggs, each time a female spawns she rids herself of appreciable amounts of these chemicals. It appears that by repeated spawning during the spring and summer the female bluegills may have reduced the amounts of these pesticides in their eggs to nonlethal levels.

Past experience indicated that this pond should support approximately 250 pounds of bluegills and crappie per acre. In September 1969, however, only 153 pounds per acre of these two species were present and none of the individual fish was more than six inches long. A number of organisms such as crayfish, snails, and aquatic insect larvae on which the fish feed appeared to be very scarce in this pond. Apparently the pesticides reduced rather drastically the amount of food available to the fish and were therefore responsible for the low poundage of fish per acre and the small size of the fishes.

In summing up the results of this study, it appears that pollution of the pond by DDT and dieldrin lowered the yield of fish by reducing both the reproductive success and food supply of the fishes in this pond.

Insight on Dutch Elm Disease

The fungus that causes Dutch elm disease produces reproductive cells in bark beetle breeding galleries formed in diseased trees. These cells "hitch-hike" on the young bark beetles from the diseased elm to healthy elms and are introduced into the wood of healthy trees as the beetles feed. Another way the fungus gets into healthy elms from diseased elms is through natural root unions called root grafts, which are common among elms. Once the fungus enters the sapwood and becomes distributed in the tree, the elm dies.

In spite of the vast amount of research that has been done on Dutch elm disease, little is known about how far and how fast the fungus moves in elm trees after it enters the tree through root grafts or bark beetle feeding wounds. Reports of research conducted in Massachusetts and Canada indicate that upward movement of the fungus in elms may be quite rapid when massive quantities of fungus cells are introduced into the sap stream. In nature, however, the actual number of fungus cells that enter a healthy elm through feeding wounds or root grafts is quite small. To find out what really happens when a small amount of Dutch elm disease fungus cells enter a tree, Survey plant pathologist Dan Neely and technical assistant James E. Schuster recently conducted a series of experiments on the upward movement of the fungus in inoculated elms.

Several drops of water containing fungus spores were introduced into the base of forty elms 12 to 16 feet in height at a point 6 inches above the ground. At intervals following inoculation, several trees were cut into segments and examined for the presence of wood discoloration, which is a typical symptom of Dutch elm disease infection. The sections were also cultured to determine the presence of the disease fungus.

Results of this study indicate that the fungus moves upward rapidly in elms. Sapwood discoloration was evident and the fungus was recovered from all parts of the trees within six days after treatment. Upward movement of the fungus occurred at the rate of 2 feet per day. In contrast, downward movement of only about 1 inch per day occurred when the fungus cells were introduced through wounds similar to beetle feeding wounds, as determined previously by Dr. Neely.

From these studies, according to Dr. Neely, we now have data to support the theory that elms inoculated through bark beetle feeding wounds in the tops of trees may require two, three, or occasionally four years to be killed, whereas trees inoculated through root grafts may die within a months time. This information greatly increases our knowledge of the highly complicated nature of Dutch elm disease.

Disappearing Song Bird Habitats

Most people, whether so-called "bird lovers" or not, agree that an abundance

of song birds is not only pleasant but desirable and worthy of preservation. Few realize, however, that our knowledge of song bird habitats and the factors that effect bird populations is sadly lacking. This fact is particularly true in relation to migrant song birds like the wood warblers which migrate south into Illinois in the fall and north again in the spring.

For a number of years wildlife specialists Frank Bellrose and William Starrett, stationed at the Survey Laboratory at Havana, suspected that during the migration season the number of transient song birds to be found in the Illinois river valley of west-central Illinois was considerably less than that found at the same latitude in eastern Illinois. Their impressions were based on casual observation and no valid scientific evidence to support their view was available until 1969, when Survey wildlife specialist Richard Graber decided to census migrant song bird populations in east-central and west-central Illinois.

In examining the census figures for the fall migration of wood warblers, Dr. Graber found that three to four times more warblers were observed in eastern than in western Illinois. Whether these differences in the number of migrating warblers are real, however, may be open to question since the availability of suitable woodland habitat for warblers undoubtedly influences any census. It has been estimated that only 1 to 2 percent of the land area in the east-central part of the state is forested (warbler habitat) compared to nearly 14 percent of the west-central part. Warblers may concentrate in the limited woodlands of the eastern areas and appear to be more numerous than in western Illinois. The fact that transient warbler populations during the peak migration period are nearly thirty times the number of nesting warblers in the east compared to two to three times the number in the west shows that such a concentration does occur in the east.

The important question arises: How much concentration can migrating song birds such as the wood warblers withstand? The increased destruction of woodland habitats by agriculture, urban sprawl, and flooding from reservoir construction is eliminating the few remaining habitats suitable for warblers and other species of song birds and it is doubtful that these birds can adapt quickly to rapidly fading habitats. By international treaty, the United States has agreed to protect migrating birds, but it is of little value to protect birds if we eliminate the habitat on which the migrants depend.

Much research over many years is needed on song bird habitats and how they can be managed to preserve populations of these desirable birds. In the time required for this research to take place, however, habitat destruction may pass the point of no return. To avoid this needless loss, some stop-gap action is required. Dr. Graber suggests that, in counties with less than 5 percent forest acreage, the cutting of woody cover, of trees and shrubs, on public-owned land be intelligently regulated. In this way the loss of song bird and migratory bird habitats can at least be slowed from its present pace.

Soybean Center

In recent years Illinois has become the nation's number one producer and exporter of raw soybeans and soybean products. It seemed logical, therefore, that Illinois should also become the center for research on the development and improvement of this valuable crop species.

With this idea in mind, entomologist W. H. Luckmann, Head of the Survey's Economic Entomology Section, worked for several years on the development of a cooperative soybean program, enlisting the talents of workers in various fields at the Survey and on the University of Illinois campus at Urbana-Champaign. This effort has finally borne fruit in the creation of a project known as the Program for International Research, and Development of Soybeans or "PIRIDS." A continuous, cooperative research program encompassing many aspects of soybean culture, plant protection, plant breeding, marketing and utilization, PIRIDS is unique and should produce much useful information for soybean growers in Illinois.

The entomology portion of this program was formalized in 1969 with the assignment

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of a Survey team composed of doctors W. H. Luckmann, E. J. Armbrust, and M. Kogan from the Economic Entomology Section and Dr. L. J. Stannard from the Faunistic Surveys Section. In addition to the Survey team, cooperating agencies currently include the University of Illinois College of Agriculture departments of Agronomy, Plant Pathology, Food Science, Home Economics, and Agricultural Economics, and the U.S. Department of Agriculture Regional Soybean Laboratory located in Urbana.

During the past year, a reference collection of scientific papers and reports on arthropods — insects and mites — and arthropod vectors or carriers of soybean diseases was established and now totals nearly five thousand abstracts, including reports from throughout the world, wherever soybeans have been grown. The abstracts have been assembled into an information retrieval system, so that any information collected is available almost immediately to workers in Illinois and elsewhere. In addition, a reference collection of mounted insects and mites is being established from collections made throughout the summer in fields of Illinois soybeans and from collections on soybeans at various international points. Many of the insects in the collection submitted by cooperators in other countries are potential invaders of the U.S. crop.

This center of published literature and identified insects will support the PIRIDS research team by providing a source of information not available in any other state. The Survey's Economic Entomology Section has therefore taken a fundamental and important step forward in the area of soybean research.

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Mr. Butterfly of Illinois

In the fall of 1948 a young man, Roderick R. Irwin, appeared in the office of the Faunistic Surveys Section and introduced himself to the staff as a freshman in chemistry at the University of Illinois and, by avocation, a butterfly collector. Twenty-two years later, he presented to the Illinois Natural History Survey his personal collection of butterflies, a legacy of twenty-five years of intensive collecting and study, especially of the Illinois fauna.

During the intervening years, Mr. Irwin was a frequent collaborator and visitor to the Survey notwithstanding serious injuries suffered in a chemistry laboratory accident at his home in Streator. The injuries made it impossible for him to continue his college education. He learned Morse telegraphy, was employed for a time by the Santa Fe Railroad, and later joined the Norfolk and Western Railway as telegrapher and teletype operator. Without interruption he continued his avid interest in butterflies, concentrating on the Illinois fauna.

Irwin's research activities on butterflies commenced in 1963 when he joined Dr. John C. Downey, then of Southern Illinois University, in the preparation of a report on the butterflies of Illinois. Field work, supported in part by a grant from the Illinois Academy of Sciences, led Irwin into remote parts of the state in search of butterflies. And it brought him into contact with other collectors. He made several study trips to large scientific institutions to consult with specialists and examine these collections for Illinois butterflies. The Illinois State Museum acknowledged his interest by giving him the title of Honorary Curator of Lepidoptera.

With the addition of the Irwin collection of approximately 3,800 pinned specimens, the Survey becomes the owner of the largest assemblage of Illinois butterflies in existence. The combined collection presently is housed in 168 museum drawers, and represents more than 150 Illinois species.

A checklist of the butterflies of Illinois, by Irwin and Dr. Downey, is nearing completion and will add to the several scientific papers which Irwin already has published.

Roderick R. Irwin curating the Survey collection of butterflies. (Photo by Survey photographer William Zehr.)

His years of devotion to his hobby, careful attention to recording the details of captures, insistence on accurate identification of the various species, and his generosity have earned for Roderick R. Irwin the reputation as the leading butterfly specialist within the state.

Garden Symphylans — Control

The garden symphylan, *Scutigerella immaculata* (Newport), is distributed throughout Illinois. Since 1967 the importance of this arthropod as an economic pest has been increasing in cultivated fields. The animal recently has been of economic importance in several Midwest states and is a problem throughout the world. Efforts in the Midwest to control this pest have generally resulted in frustration. Since garden symphylan is of such potential importance, another attempt to control it was made during 1969 by Survey entomologist R. E. Sechriest.

Three fields known to have economic infestations of garden symphylans were selected and identical experiments were attempted in them. The infestation in one field near Illinois City in western Rock Island County resulted in an economic problem and excellent data were obtained. These animals were present and feeding on the corn roots all season (until November) and the number of animals was estimated to reach 150–200 per corn plant.

Seven different insecticides were evaluated at different rates per acre applied as broadcast and band treatments. Other than different insecticide treatments all other normal cultural practices were equal. Ten different major evaluations were made, such as initial stand counts, numbers of weak plants, wilted plants, lodged plants, plant height, number of tassels, number of silked plants, yield per acre, moisture of shelled corn, and a total composite rating. These were taken at various times during the season. Within the experimental field near Illinois City each different treatment was randomly placed in the test field at three locations in an effort to account for varying factors such as soil type, soil moisture, and symphylan infestation, and for mathematical analysis of the resulting data.

No significant difference was observed in the initial stand counts. Measurable precipitation was recorded on an unusually high number of days this past season at the test site and differences were not as clear-cut at the last of the season as at the start. Nevertheless, significant differences can be observed in the data. Broadcast treatments provided the best control. For instance, four more bushels per acre of number 2 corn were produced in the Dyfonate broadcast treatment than the band treatment. The band treatment produced twenty bushels more per acre than the untreated (even with high moisture all season). The untreated corn had significantly fewer tassels and silks. When the corn was harvested by combine, the shelled corn from treated areas had 1–2 percent less moisture than the untreated. The treated corn produced significantly more corn and matured earlier than the untreated corn.

Dyfonate resulted in the best suppression of symphylan populations. In fact, Sechriest believes it will give 99.9 percent kill of the garden symphylan. Other available materials which provide some benefit are VC-13, TZ-67 (Thimet plus Zinophos), Mocap, Niran, and Furadan. The Illinois recommendation is Dyfonate applied at two pounds broadcast or one pound in a band.

Winterkill of Fishes

Mildly polluted lakes, ponds, and small rivers that support fishes without serious losses during spring, summer, and fall sometimes develop adverse conditions for fishes in winter when these waters become completely frozen over and the ice is covered with an inch or more of snow. Under these conditions, the main source of oxygen in the water under ice is from photosynthesis of aquatic plants, and/or algae. Photosynthesis is the process in which the green plants in the presence of light are able to produce starch from carbon dioxide and give off oxygen as a by-product. This free oxygen rather quickly dissolves in the water and be-

Dr. Childers testing a polluted Champaign County river for dissolved oxygen. Tests on January 23 showed 6 ppm or more of dissolved oxygen, indicating no shortage for fishes. (Photo by Dr. George W. Bennett.)

comes available for respiration of fishes and other aquatic animals. Enough light for a low level of photosynthetic activity will pass through as much as 15 inches of cloudy ice. But 1 inch of crusted snow on top of thick cloudy ice will cut out nearly all light, and 5 inches of snow will form a light-tight curtain over the ice.

When the light is cut off by snow on ice all photosynthesis stops, and if the condition exists for a long enough time, the processes of respiration by fishes, other aquatic animals, and bacteria in the water under the ice will use up all of the available dissolved oxygen and the fishes and other animals suffocate. The dead fishes may not be observed until the ice goes out in the spring and they decay and float to the surface.

The loss of fishes under ice due to an oxygen deficiency is known as *winterkill.* If all of the fishes were killed, it might become a simple matter to restock the lake or pond at one's leisure, with recommended numbers of desirable kinds of fishes. Usually, however, the more desirable kinds of fishes are killed, leaving the undesirable kinds to reproduce and repopulate the water. Once this has taken place, it is quite useless to restock desirable fishes until the undesirables and their progeny are removed. Winterkills in rivers are less serious because fish may quickly repopulate the "killed" areas through migration.

In some ponds and small lakes oxygen deficiencies can be helped by pumping air through perforated tubes laid on the pond bottom. The upwelling air containing some oxygen carries bottom water, which is a few degrees warmer than the water under the ice, upward to melt the snow-covered ice above. This process may also stir up loose organic silt on the bottom which itself may have a high oxygen demand.

With the right equipment in relation to pond size, flooding the surface ice with water from below will melt the snow and allow photosynthesis to be resumed. However, in many larger locations, almost nothing can be done to prevent the loss of some or most of the fishes.

Luckily, conditions that produce win-

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terkill in Illinois lakes and ponds do not occur every winter, as periods of thawing usually melt the snow covering before it has been on long enough to result in oxygen deficiencies under the ice. So unless the snow cover lasts for five or more weeks in waters not subjected to unusual sources of organic pollution, there is little danger of winterkill of fishes. It is of some interest to follow the gradual reduction of dissolved oxygen under ice during the winter period which is readily accomplished by suspending the electrode of a battery-powered oxygen analyzer into the water at various depths below the surface of the ice (see illustration). With this instrument predictions of winterkill can be made, even if little can be done to prevent it.

Tell-tale Body Heat

A full understanding of the annual and year-to-year fluctuations in the number of animals of a particular species cannot be achieved without knowledge of mortality factors such as when, under what conditions, and by what agents animals die. A technique for this kind of study is being worked out by the Survey's wildlife specialist William W. Cochran. The telemetry transmitter (radio-tracking equipment), used for many years to determine animal movements, is not satisfactory for a study of mortality factors because the time required to keep track of the large sample (perhaps one hundred individuals) necessary for mortality studies is prohibitive.

A thermistor switching circuit has been developed which energizes a transmitter only when its temperature drops below a preset value. While the animal is alive, its body-heat keeps the transmitter off, but when the animal dies the lowered temperature causes the transmitter to turn on. By placing all transmitters on the same frequency, monitoring of large numbers of individuals can be done quickly and periodically. Only recently-deceased animals require attention. The transmitter can be made light-weight and long-lasting because it remains off — except for a very small idling current — until the animal bearing it dies.

One problem to which this device will be applied is to determine the cause and extent of the pre–hunting season mortality in cock pheasants. The recovery rate of numbered back-tags from hunters is greater for pheasants tagged just before the hunting season than for those tagged a month earlier. This indicates that considerable mortality occurs prior to the hunting season when food and cover appear to be plentiful. By adding the radio to the numbered back-tag, the pheasants — or their remains — can be collected shortly after death, and hopefully, with a little detective work, the causes of deaths can be categorized.

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Post-Mortem for Twin-City Elms

Millions of American elms have been killed in Illinois and surrounding states by the virus disease phloem necrosis and by Dutch elm disease caused by a fungus. Now that American elms are all but gone from many cities in the Midwest, many people have wondered how and why such devastation came about. As most communities did not wake up to the fact that their elms were diseased until many trees were dead and dying, case histories of elm disease epidemics in cities are very rare. In addition, many communities attempted some form of disease control — usually too little or too late — which affected the elm disease cycles and made records of the waxing and waning of elm disease epidemics invalid.

A unique history of disease losses of American elms has been compiled for the twin cities of Champaign-Urbana through the efforts of Survey plant pathologist J. C. Carter and his wife Lucile. Conducting research at the Survey on diseases of elms and other shade trees since 1934, Dr. Carter has been in a position to observe and record elm disease epidemics in the twin cities from the first case of infection to the present day. These records are of value in that no disease control programs for elms were conducted in the twin cities except on the University of Illinois campus. The elm plantings were continuous throughout the two communities and could be considered as one large elm population, interspersed with approximately the same number of trees of all other species. The data collected by Dr. and Mrs. Carter therefore give a clear picture of the normal cycle of two of the most destructive shade tree diseases, phloem necrosis and Dutch elm disease, and how they interact when these diseases are present at the same time, as has been the case in many Midwest communities.

Phloem necrosis, a virus disease of elm transmitted from tree to tree by leafhoppers, first appeared in Urbana in 1944 and in Champaign in 1948. In 1944, Dr. Carter with the aid of Mrs. Carter initiated a series of annual surveys of the twin cities to obtain data on the rate of increase in the number of elms affected by phloem necrosis. With the appearance of Dutch

Disease-killed elms in Urbana, a common sight in 1953. (Photo by former Survey photographer W. E. Clark.)

elm disease in Urbana in 1951 and in Champaign in 1952, data were recorded on the incidence of both diseases as determined by two surveys annually. Each survey, made by automobile, covered 200 miles of streets, 75 miles in Urbana and 125 miles in Champaign. Trees were examined periodically to insure that the diagnoses were accurate.

In the twin cities, both phloem necrosis, and Dutch elm disease increased and spread slowly for several years following their initial appearance. After this slow start each disease spread rapidly. Phloem necrosis, the first to appear, killed few trees and spread slowly the first five years. By the time Dutch elm disease appeared in 1951, phloem necrosis had reached epidemic proportions. Trees dying from this disease were excellent breeding grounds for the elm bark beetles that spread Dutch elm disease, and beetles were present in large numbers. Thus the stage was set for Dutch elm disease when the fungus was introduced into the twin cities in 1951. Dutch elm disease became epidemic within three years after its first appearance.

Although less than 10 percent of the Champaign-Urbana elm population had been killed before 1952 when phloem necrosis was the main disease, over 89 percent of the entire elm population succumbed to both diseases between 1952 and 1961. With less than 1 percent of the elms remaining after 1961, the annual loss has been reduced to only a few trees in recent years. Of the original population of 14,103 elms in the twin cities, all but 56 had been killed by the fall of 1969, a period of 26 years. Dutch elm disease killed 11,057, or 78.41 percent, of the trees and phloem necrosis killed 2,983, or 21.17 percent. In general, this same pattern of dying occurred in many other Illinois cities.

The Carters's surveys showed that once these diseases reached epidemic proportions they continued to spread and kill trees until the elm population was for all practical purposes eliminated. No instances of resistance to Dutch elm disease were found, and only one tree appeared to have some resistance to phloem necrosis although this tree was killed by heavy bark beetle attack. As bark beetles, which carry Dutch elm disease, breed in trees dying of phloem necrosis, Dutch elm disease spreads rapidly in areas where phloem necrosis is present. The incidence of phloem necrosis, on the other hand, is not affected by the presence of Dutch elm disease because leafhoppers feed only on foliage and do not require diseased trees for breeding.

Although the surveys made by Dr. and Mrs. Carter were not intended as part of any control program, they present a very unique and useful picture of what can happen when tree diseases with epidemic potential are introduced into a heavy population of susceptible trees. This information reinforces the Survey's recommendations for shade trees, which include planting communities with varied tree species and exercising the prompt use of whatever control measures are available when a potentially epidemic disease appears.

Hunting Regulations and Pheasant Kills

One of the goals of wildlife management is to establish hunting regulations which result in a harvest rate of game species that allows for the survival of a favorable population of these animals. At first glance this would seem to be a simple matter of relaxing hunting regulations when higher harvest rates are desirable and adopting more restrictive regulations when a lower harvest is desirable. In practice, however, the relationship between hunting regulations and harvest of wild game has proved to be considerably more complex.

Each year since 1962, Survey wildlife ecologists S. L. Etter and R. E. Greenberg, cooperating with the Illinois Department of Conservation, have estimated the harvest rate of cock pheasants on a 36-square-mile study area in Illinois. These estimates were based on the change in sex ratios of pheasants observed before and after the hunting seasons.

In 1962, 1963, and 1964, when a bag limit of three cock pheasants was in force, estimated harvest rates were high, ranging from 70 to 75 percent of the cocks available to hunters. With a two-bird bag limit in force in 1965 and 1966, the harvest rates

New facility for insect studies at the Morton Arboretum, Lisle, Illinois. (Photo courtesy of William S. Stickney.)

were 46 and 53 percent respectively. In 1967 the two-bird bag limit remained in force, but the hunting season was extended by fourteen days because of a low pheasant kill resulting from unusually large acreages of standing corn. The harvest in 1967 was 36 percent. Longer hunting seasons and the two-bird bag limit were continued in 1968 and 1969, with a resulting cock pheasant harvest of 54 and 44 percent respectively.

Compared with later years, the higher cock pheasant harvest rates in 1962, 1963, and 1964 apparently resulted from a combination of much higher pheasant populations and the three-bird bag limits then in effect. The similarity of the harvest rates in 1965 and 1966 to those in 1968 and 1969, when population levels and hunting conditions were similar, suggests that the longer seasons in the latter two years had little effect on the harvest of cock pheasants. Thus, while larger bag limits when pheasant population levels are high may increase harvest rates to some extent, pheasant hunting appears to be largely self-limiting. Once the number of available cocks has been reduced to a certain level, the effort required to bag a bird becomes so great that few hunters continue hunting no matter how liberal prevailing regulations are.

Information such as this is very valuable in formulating hunting regulations that permit the most freedom for Illinois hunters consistent with the maintenance of suitable populations of game species.

New Facilities for Insect Studies

Although much research has been done on the insect pests of crop plants in Illinois, information is lacking on many of the more than 150 species of insects that attack ornamental plants in the state. One of the main drawbacks to obtaining information on these insects has been the lack of research facilities to study insects in areas of the state where they are causing damage. The life cycles and feeding activities of many insect pests are quite variable depending upon where they are found in the state. In addition, detailed studies on the relationships between insect pests and their host plants, particularly trees and shrubs, are difficult or impossible unless the studies are conducted in areas where the host plants are growing.

An ideal location for conducting research on insect pests of ornamental plants is the Morton Arboretum at Lisle, Illinois. The Arboretum contains plantings of nearly all species and varieties of trees, shrubs, and other ornamentals that are grown in Illinois, as well as many specimens from other parts of the world. This wealth of plant

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material is available for scientific research as well as for the enjoyment of the public, and many research projects at the Arboretum have been conducted in the past by Survey staff members.

In the spring of 1969, the Board of Directors of the Morton Arboretum approved a long range research project submitted by Survey entomologist J. E. Appleby on the study of life histories of insects attacking trees and shrubs. Included in this project was the construction of an indoor-outdoor insect laboratory which was completed in November of last year. This facility is a wood frame building divided into a 14- by 10-foot air-conditioned office-laboratory, and a 14- by 31-foot screened outdoor area. Along the walls of the screened area are tiers of shelves where growing plants and cages for insects may be placed. A plexiglass strip covering part of the screening prevents high winds from damaging the insect cages, and removable glass frames in the roof at one end allow sunlight to enter so that plants can be grown under nearly normal conditions. The glass frames may be removed during the winter months to expose the plants and insects to precipitation. In this manner, insects can be studied under natural field conditions.

With this facility now available, Dr. Appleby hopes to find answers to such questions as where and how long immature stages of insect pests of ornamentals feed and how many generations of these insects there are each year. He also plans to study the parasites and predators that attack plant-feeding insects to determine whether these natural insect enemies can be used in addition to, or in place of, insecticides in devising effective control programs.

A similar insect laboratory has been proposed for southern Illinois as the insects that attack ornamental plants in that part of the state are quite different from those found in the northern areas.

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Petty Receives Service Award

Professor H. B. Petty of the College of Agriculture and the Survey's Cooperative Extension Service has received a Superior Service Award from the United States Department of Agriculture. Chosen together with several other agriculture specialists from among more than sixteen thousand USDA personnel throughout the United States, Dr. Petty was cited for "effective leadership, creative efforts, and diligent service in helping to assure wise and safe use of insecticides and all pesticides."

Known as Pete to his co-workers and to many Illinois farmers, control operators, and pesticide dealers, Dr. Petty has helped bring the results of research on pesticides and their use directly to the people handling these materials. He publishes a column in *Prairie Farmer* which reaches many farm folk. He or members of his extension group appear weekly on a TV program which is followed by many backyard farmers as well as rural people.

For twenty-one years he has held the Custom Spray Operators Training School in January to keep commercial applicators, dealers, and farmers abreast of advances in knowledge concerning pesticides and their usage. The *Weed, Disease, and Insect Survey Bulletin,* a weekly publication, has been his unique approach to reporting current and potential insect problems and their control.

Dr. Petty has initiated chemical dealer clinics and a newsletter to all chemical dealers in Illinois to keep them abreast of new developments. He encourages dealers to stress the importance of the correct use and safe handling of pesticides to their customers. Not forgotten by Pete are the small-package dealers who sell pesticides primarily to urbanites for use in their yards. Clinics for these distributors have attracted hundreds of interested dealers.

Dr. Petty has been with the College of Agriculture for thirty-one years and with the Cooperative Extension Service for twenty-nine years. The Survey personnel are proud to have Dr. Petty associated with them, and we wish to extend our congratulations to him for receiving this well-earned award.

Computer Ecology

A natural assemblage of plants and animals (a community) is very complex, and the number of interactions that may occur between these organisms is virtually infinite. The ecology of a hay field is roughly equivalent to the economy of the United States. It may be easy to understand the economics of one person (he may buy a car, rent a house, save some money), but the economy

H. B. Petty, of the Illinois Natural History Survey. (Photo by Survey Photographer Wilmer Zehr.)

of the entire country may be very difficult to understand or to predict. How raising the cost of steel a dollar a pound affects the number of tubes of toothpaste purchased in a year, for example, would be difficult to predict. Roughly the same problem is faced by the ecologist who must predict the consequences to all of the species in a community of the addition of, for instance, two pounds of phosphorus per acre to a field.

Most people recognize the problems of pollution resulting from the addition of pesticides to cut down on the numbers of pests on crops. Unfortunately, at the present time there are not many alternatives to their use although advances are being made in biological control methods. One aim of ecology is to understand a community of plants and animals well enough that it may be possible to control a pest without the use of pesticides or with a pesticide whose effects are limited to that species.

An attempt is being made by entomologist Robert W. Poole to develop a computer technique to predict changes in the ecology of an area, principally by using a method known as factor analysis. Basically, the technique assumes that a series of factors such as rainfall, iron in the soil, or pesticides cause the changes in numbers of each species of the community. First, the changes in numbers and the kinds of changes are observed. Then the statistical technique is applied to predict the number of factors that are causing the changes, and to estimate the amount of change in numbers caused by each factor. It is not necessary at first to know what these factors are, only to recognize how many factors exist. Then field work is needed to identify environmental equivalents of the factors derived from the factor analysis. If the two or three most important factors are identified, the technique yields a series of equations for each species, predicting the changes in a species population if any factor — such as rainfall — changes.

A high-speed computer is needed for the calculations, and the use of factor analysis on a moderately sized group of species (about 150) would have been impossible even five years ago. If the "organization" of such groups of organisms were known, it might be possible to lower the numbers of a pest species by such measures as increasing the numbers of another species in the community, or by changing some environmental factor that would have less lasting consequences than the addition of a persistent or nonspecific pesticide.

The Year of the Cicada

In China 1970 is the year of the dog, but in Illinois and much of eastern United States it is the year of the cicada. Brood X of the seventeen-year cicada will appear this year in most of eastern Illinois from Chicago to Cave-in-Rock. What is commonly known as the seventeen-year cicada includes three almost identical species of cicadas which were first distinguished by differences in their songs. A few stragglers of this brood appeared last year in the Chicago area.

Brood X of the seventeen-year cicada is thought to be the largest brood and always emerges in abundance. It was last observed in 1953 when it appeared in most of the eastern tier of counties in Illinois from Will in the north to Pope in the south and as far west as Jackson, Morgan, and Knox counties. Another outbreak in Illinois occurred in 1963 when Brood III of the seventeen-year cicadas and Brood XXIII of the thirteen-year cicadas came out together. Brood XXX of the thirteen-year cicadas will also appear in 1970, but it is confined to Louisiana and does not reach Illinois.

Survey entomologist Lewis J. Stannard, together with other Survey personnel, intends to make accurate records of Brood X during the 1970 emergence in order to better determine their range and exact location. Because three species are involved, collections of actual specimens will be made and reliance on the songs of the three will be minimized, although they are distinguishable by experts.

Periodic cicadas are not mere curiosities of the natural world. Occasionally they cause damage to orchards and forests by weakening the terminal twigs of trees during egg-laying. The female cicada cuts into

The periodical cicada; in life the wing veins are red or orange, unlike most other cicadas. (Photo by Survey Photographer Wilmer Zehr.)

small branches with her sawlike ovipositor and inserts her eggs into these slits. The nymphs, after hatching, fall to the ground, burrow down and feed on roots for the next sixteen years. They then emerge in the seventeenth year to mate and begin the cycle again.

Our periodic cicadas should begin to appear in mid-May in the south and in early June in northern Illinois, depending upon the caprices of the weather. One or more weeks ahead of emergence, the nymphs make exit holes in the ground often capped by turrets. These holes can be used to forecast the numbers of cicadas coming out as adults in an area.

Information from Illinois residents on the occurrence of Brood X in Illinois will be appreciated by Survey scientists. However, in all cases specimens will be needed to verify the species involved.

Environmental Crisis Week

Illinois is blessed with an abundance of natural resources, but as its population increases and the demands on these resources increase, we begin to realize that each resource has a limit. Some resources, such as coal, are consumed; others can be used and reused many times without being destroyed. These reusable resources — soils, water, air — support the living resources of our state and thus are related to the work of the Survey whose responsibility it is to protect and use wisely the plant and animal communities of Illinois.

But even renewable or reusable resources can be destroyed. Our water supplies, for instance, can be used by industry, can irrigate our crops, provide recreation, carry effluent from waste disposal plants, and serve a vast number of purposes. On the other hand, water may be so severely abused and reduced in quality that it may be unfit for any of these purposes.

At the suggestion of Senator Gaylord Nelson, April 22 was set aside as a day to recognize and study the resources of our country and to analyze the impending environmental crisis. At the University of Illinois, the Students for Environmental Controls expanded the proposed teach-in day to Environmental Crisis Week covering more than seven days and involving many departments of the University and the three scientific Surveys. Speakers were brought from all over the country to discuss their particular environmental specialty.

The Natural History Survey has had an active part in the planning, formation, and activities of Environmental Crisis Week. Mr. Robert O. Watson and Dr. R. Weldon Larimore represented the Survey in the planning work. Dr. George Sprugel, Jr., served on a panel that considered the many problems being brought on by our rapidly growing population. Also, he was chairman of a workshop that considered "Water Use, Requirements and Resources." Contributions to the workshop by Survey staff members included a case history of a small Illinois stream by Warren U. Brigham, and the pollution history of the large, highly industrialized Illinois River by Dr. W. C. Starrett. In other technical workshops,

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Dr. William H. Luckmann discussed pesticides in high-production agriculture, and Dr. Glen Sanderson described the significance of wildlife as an indicator of environmental quality. Some of these Survey scientists contributed their efforts to environmental crisis meetings conducted on several other college campuses in Illinois.

The Natural History Survey served as host to Dr. Paul Sears, Yale University, and Dr. Stanley Auerbach, Oakridge National Laboratory. Both scientists presented technical discussions during the week and visited various members of the Natural History Survey staff.

The involvement of the Natural History Survey in Environmental Crisis Week has served to educate the students and the general public to our environmental crisis. In addition, the Survey's technical staff has benefitted from the exchange of information and review of problems.

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Choosy Soybean Chompers

Insect-plant associations result from a long and complex evolutionary process. The study of how and why insects choose soybeans as their preferred food is part of a new project initiated by the Survey's Section of Economic Entomology.

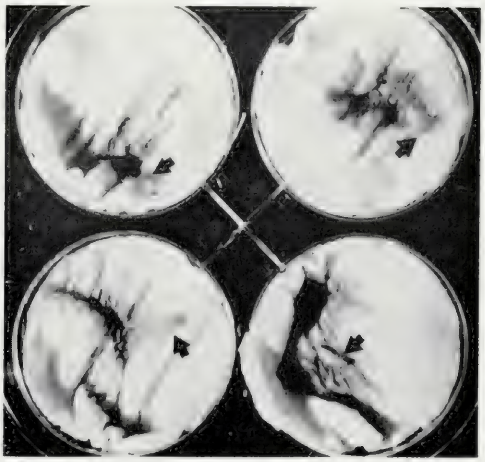
Most damage caused by plant-eating insects stems from their peculiar feeding habits. During their larval development, many species eat continuously, consuming huge amounts of plant material in the process and increasing their body weight by several hundred times. However, most insect species do not eat just any available plant. Some, such as grasshoppers, are indeed very general feeders and readily accept a large variety of plants as food, but even grasshoppers are restricted in their range of food plants. The females of some species are known to bite and probe a plant before depositing their eggs, thus assuring a suitable food source for their offspring. Many more insects limit their menu to a very few plants. In general, the plants they accept as food have in common some important type of chemical compound.

The Mexican bean beetle is a well-known pest of bean plants and causes economic damage to soybeans in southern states. It is also a potential pest of soybeans in the Midwest. This species was selected by Survey entomologist Marcos Kogan for use in model studies designed to uncover the physiological and behavioral bases of host plant selection by insects associated with soybeans.

The strain of Mexican bean beetle used in Dr. Kogan's experiments was collected on soybeans in central Indiana. Studies have shown that soybeans are an adequate food for these insects. During larval development, which takes approximately 20 days, their weight increases 150 times, and each larva may consume the sap content of a regular size trifoliate soybean leaf.

To study the factors influencing host selection a new, nutritionally-defined artificial diet was developed on which the beetle larvae could be reared. When plant fractions are added to this diet, its acceptance by the larvae may be enhanced or reduced, depending upon whether the plant itself encourages or inhibits feeding. This effect is measured by variations in the growth rates of the larvae. When some inhibitory activity is detected, the plant fractions are analyzed and hopefully the compound or compounds involved are isolated.

When plant breeders have this information, they may be able to produce



Mexican bean beetle larvae (arrows) feeding on an artificial diet. (Photo by Dr. Kogan.)

soybean plants that are no longer suitable for the development of insects, thus becoming immune to their attack. The question of why some plants are resistant to insects is only one of many that may be answered by studies of host plant selection. Many of these answers may have a direct impact on the future of soybean insect control.

Age and Egg Production in Pheasants

A hen pheasant lays many eggs during her lifetime, and most of the eggs do not hatch or produce birds that survive to become adults. Wild hens often drop eggs outside nests or lay eggs in nests other than their own. If first nesting efforts are unsuccessful, they often renest, laying more eggs. Egg-laying capacity, therefore, is very important in maintaining high populations of these valuable game birds. Yet, little is known about the seasonal laying capacity, and hence the production potential of hen pheasants of different ages. For each one hundred hens entering the spring season in east central Illinois, about fifty-six will be breeding for the first time (yearlings), thirty-seven will have completed one breeding season (two-year-olds), and seven will have completed two or more seasons.

To obtain needed knowledge on the reproductive capability of hen pheasants of different ages, Survey wildlife specialist Ronald F. Labisky and University of Illinois endocrine physiologist Gary L. Jackson studied egg production in a captive population of yearling and two- and three-year-old hens. The hens were provided with abundant food and water, and eggs were collected and weighed each evening during the laying season.

Two-year-old pheasants laid a greater number and a greater weight of eggs seasonally than did either yearlings or three-year-old hens, and in doing so, lost less body weight per egg. In addition, supportive field studies by Labisky indicated that two-year-old hens nested earlier and laid larger clutches of eggs than did yearling hens. Consequently, two-year-old hens may contribute more young to pheasant populations annually than their relative numbers in the breeding flock would indicate. Thus, in any harvest-management program where hen pheasants are to be included as legal game, careful consideration must be given to protecting those hens that will constitute the two-year-old breeders in the following spring.

In Illinois, Dr. Labisky has found that, due to natural mortality of juvenile hens in fall and early winter, the hen population present in late fall and early winter has a high proportion of adult hens. Thus, the later into the autumn that hen shooting is permitted, the greater number of adult hens that will be killed. Hen pheasants have never been legal game in Illinois, but there has been considerable pressure at times to change these regulations. Permitting the killing of adult hens would constitute an obvious danger to Illinois pheasant populations.

Bugged Bunnies

The habits of cottontail rabbits have been difficult to study because of their nocturnal nature and wide range of their habitats. Their activities during the winter months have been especially hard to observe due to severe weather conditions.

An ingenious method for studying cottontail movements during the winter was evaluated recently by former Survey wildlife researchers J. C. Hanson, J. A. Bailey, and R. J. Siglin as part of a cooperative project between the Illinois Natural History Survey and the Illinois Department of Conservation. Sixteen cottontails — seven males and nine females — were fitted with small radio transmitters and radio-tracked during winter nights on the University of Illinois orchard near Urbana. Several types of habitats and food sources were present in the study area and the preference of cottontails for both habitat and food source under various weather conditions was studied.

By tracking the nocturnal movements of the test animals during different types of weather conditions, they found that the rabbits moved about without showing much apparent preference for habitat whether or not there was light snow on the ground. On a night with 4 inches of heavy wet snow on the ground, however, the cot-

tontails sought areas with dense, woody cover. Under blizzard conditions with high winds, they showed a preference for the habitat which offered the most protection.

On nights with little or no snow, the test rabbits appeared to make use of grassy areas or a sparse stand of fall-planted oats for feed. Under heavy snow or blizzard conditions, they seemed to remain in areas of heavy cover and probably did not forage much for food.

Although radio-tagging enabled the Survey researchers to follow movements of cottontails, they felt that more meaningful information could be obtained if all animals within a population were tagged, habitat types were more clearly defined, and the social structure of the rabbit population were studied to see if movements were influenced by the presence of different territorial or breeding groups.

This research will undoubtedly lead to more refined and useful techniques of studying cottontail movements and habitat preferences and eventually be of help in the management and preservation of these and other animals native to Illinois.

Blue ash showing symptoms of Verticillium wilt. (Photo by Dr. E. B. Himelick.)

Verticillium Wilt of Trees

A soil-inhabiting fungus known as *Verticillium albo-atrum* invades the sapwood and causes wilting in many species of trees and other woody plants. Due to the wide host range and distribution of the fungus throughout the United States and the world, Verticillium wilt is one of the most common and destructive diseases of trees and shrubs. Like Dutch elm disease and oak wilt, Verticillium wilt is an internal or vascular disease which causes plugging of the water conducting vessels in the stems of affected plants and results in wilting and death of branches and occasionally entire plants.

The disease is conspicuous because the leaves on affected plants wilt or turn yellow in early summer and die as the fungus, which usually invades the plant through the root system, spreads slowly up the trunk and into the branches. The invaded sapwood shows a characteristic brown discoloration in most tree genera and heavily infected trees have branch dieback and are stunted. Many trees and shrubs show wilt symptoms after they have been transplanted from nursery fields to landscape plantings.

Although Verticillium wilt is a common problem on woody plants, certain facets of the disease cycle are not clearly understood. To shed some light on how and why plants become infected and how the fungus causes wilt symptoms, Survey plant pathologist Gerald Born conducted an extensive series of tests using tulip tree, green ash, redbud, sugar maple, Russian olive, and barberry, all of which are susceptible to Verticillium wilt.

Results of these tests showed that root pruning or wounding that commonly occurs during transplanting operations provides many open wounds through which the fungus can invade the plant and is probably one reason many plants come down with the disease following transplanting. Since the fungus may be present in the soil and can enter the plant through the roots,

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sterilizing or treating infested soil would seem to be a logical control measure. Born found, however, that the Verticillium fungus grew rapidly in sterilized soil and caused much more damage than in untreated soils. This is probably because the fungus does not compete well with other soil organisms that are normally present and is actually inhibited by these organisms. In addition, the Verticillium wilt fungus is not free-living in soil, but it is present in the soil on plant debris from previously infected hosts.

From these tests, it appears that root wounding is highly important and should be kept to a minimum during transplanting. In addition, species susceptible to wilt should not be planted in soil that has a past history of Verticillium wilt damage. Sterilizing or treating soil to control wilt may result in more disease and is probably not a good control measure.

A microscopic examination of the vascular tissues of infected trees revealed that the production of gums and balloon-like structures called tyloses in the water conducting vessels varied considerably in the different host species. In many cases plugging of vascular tissues was not extensive enough to account for the wilt symptoms observed. According to Born, the Verticillium wilt fungus may produce a toxic substance which is involved, perhaps along with plugging, in causing wilt.

Research such as this provides valuable information on how and why plant diseases occur and serves as a basis for intelligent disease control recommendations.

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Success Story

A situation ideal for testing the possibility of eradicating houseflies from a barn was brought to the attention of Survey entomologist Bob Pausch in early spring of this year. Ellsworth Bishop owns a swine farm near Varna, Illinois. Bishop's swine breeding operation centers in two barns — a farrowing barn and a young-pig barn. These barns are constructed essentially the same with air circulated by large fans through screened windows, closed doors, and slatted floors over basements filled with water to prevent fly breeding in the manure. One barn remained free of houseflies; the second supported a high population of flies summer and winter. Since the barns are heated in winter, it was evident that the flies must be breeding in swine manure which did not get completely covered by water in the basement of the second barn. Bishop has had to use insecticides in the second barn in a continuous year-round spray program.

The concept of insect control through sterilization is based in part upon a biological island concept. That is, the population of insects to be controlled by sterilization techniques should be in some way a restricted population so that migration of insects into the area do not completely defeat the efforts to reduce the population through sterilization. Bishop's swine barns, excluding flies as they do, seemed ideal for these techniques.

On April 20, 1970, two hemp cords impregnated with a sweet bait containing the sterilant (3 percent Metepa) were hung by Dr. Pausch in the fly-infested barn. At this time the level of fertility in the housefly population was near 100 percent. Each week thereafter the farm was revisited and a random collection of adult houseflies was made. These flies were brought to the laboratory and allowed to lay eggs and the eggs to incubate. From this sample of eggs, researcher Pausch and his staff could obtain accurate data on the level of fertility of the houseflies.

From the start of the experiment, the level of fertility has declined. After two months time fertility has been reduced from near 100 percent to about 5 percent with a concurrent reduction of adult houseflies in the swine barn. By the end of June it became difficult to find enough flies in the barn to bring back to the lab for testing.

It is believed by entomologist Pausch that in this, as well as other such isolated situations, baited chemosterilants alone will be able to maintain control of housefly populations. It is possible that the entire fly population may be eradicated from this barn and other similarly enclosed buildings.

Rare River-Resident

In 1905 Survey scientists S. A. Forbes and R. E. Richardson described a strange new sturgeon from the Mississippi River. They based their description on nine specimens secured by commercial fisherman near the mouth of the Missouri River. Some of the specimens were sent to Russian ichthyologists, but five of the original series were deposited in the collections of the Natural History Survey as types of the new species and new genus.

This bizarre fish, now known as the pallid

sturgeon (*Scaphirhynchus albus*), is one of the least known American fishes. Since its discovery only twenty-five or thirty more specimens have been found, and most of them have been taken by commercial fishermen in the Missouri River. The second Illinois collection was in 1944, when an angler caught a small specimen near the mouth of the Missouri River and presented it to Survey biologists W. C. Starrett and P. G. Barnickol.

In an effort to determine if the pallid sturgeon still occurs in Illinois waters, L. M. Page and P. W. Smith contacted commercial fishermen along the lower Mississippi River in 1969 and left with them jars of preservative and lists of fish species desired. The effort was rewarded in the spring of 1970, when fisherman Paul Kimmel of Wolf Lake, Illinois, captured a pallid sturgeon in the Mississippi River a few miles above the mouth of the Ohio River and preserved it for the Survey collections.

The pallid sturgeon differs primarily from the much more abundant shovelnose sturgeon in that its inner pair of barbels (whiskers) are only half as long as the outer pair and in that it attains a much greater size. The largest specimen known of the pallid sturgeon weighed 68 pounds. The shovelnose rarely exceeds a weight of 5 pounds.

The pallid sturgeon is confined to the silt-laden Missouri and lower Mississippi rivers. It apparently occurs in Illinois only in the Mississippi between Grafton and Cairo. This rare fish is of great scientific interest because it is extremely primitive but at the same time highly specialized to live on the bottom in the swift-flowing channels of our largest rivers.

Brown Recluse in Illinois

Approximately 255 specimens of the brown recluse spider (*Loxosceles reclusa*) have been collected in Illinois since 1959 when it was first discovered in the southern part of the state. Most of the specimens were obtained from 1967 through 1969 because a great deal of publicity was given to this spider. The names "brown recluse spider" or "fiddler spider" have become very familiar to Illinois residents during the last five years. Unlike the black widow, of which only the female is poisonous, both sexes of the brown recluse spider are poisonous. This spider is medium-sized with a light brownish body about three-eighths of an inch long and dark brown legs. Its most distinguishing feature is a broad, dark fiddle-shaped mark extending down the back of the head region (see illustration).

In Illinois the brown recluse is commonly found in and around houses, and thus is brought into close proximity to humans. Survey entomologist John Unzicker suggests that anyone who suspects that they have been bitten by a brown recluse consult a physician immediately. This is especially true for anyone allergic to insect or spider venoms. If at all possible, the spider responsible should be collected in a small vial for verification of the species involved.

The spider's venom attacks the cells of the skin and flesh resulting in a wound which is painful and slow to heal. Reports of brown recluse bites have tended to alarm people, but due to the low population levels of the spider in Illinois bites occur infrequently and deaths from bites are quite rare in any area.

The Survey collection now includes specimens of the brown recluse spider from 45 of the 102 counties in Illinois. It is known to occur from the Wisconsin border in the northeast to Cairo and from Quincy in the west to the Indiana border. This spider has not been reported from the northwestern quarter of Illinois and specimens from that area are especially wanted by the Survey's specialist. If spiders in or near the home are thought to be brown recluse spiders, please mail specimens of them — preferably in a small vial or bottle or pillbox — to the Survey in care of Dr. John Unzicker.

Aquatic-weed Control

Over a period of more than ten years aquatic biologist Robert C. Hiltibran has been studying the control of aquatic weeds in certain ponds in Illinois. He found that these weeds are a curse that can be controlled only by continuing efforts, as any avid gardener knows.

A female brown recluse spider showing typical violin-shaped mark on "head" region. (Photo by Survey Photographer Wilmer Zehr.)

In one study begun in 1960 an attempt was made to eradicate curlyleaf pondweed, *Potomageton crispus,* from Mansion Pond in Allerton Park near Monticello. In the years 1960 through 1962 two growths of curlyleaf, one in May and one in September, were eradicated using the herbicide liquid endothall. In 1963 and 1964 it was only necessary to apply the herbicide once in May or June and in 1965 and 1966 no herbicide was needed. However, small stands of curlyleaf pondweed began recurring and were individually treated from 1967 through 1969. It seems that, although good control of this weed can be maintained, the weed cannot be eliminated completely and a continuing control program is needed.

After the initial removal of curlyleaf pondweed from Mansion Pond, other aquatic weeds became abundant. Chara, present in 1959, became abundant and after a natural die-off in 1963 remained under control using the herbicide dichlobenil to remove stands of Chara in 1965 and 1966. Filamentous algae also became a problem and herbicides were applied for its control in certain years from 1961 through 1969. At present researcher Hiltibran reports that aquatic plants have been under control in Mansion Pond since 1962. However, this success is due to periodic inspection and application of herbicides to control small stands and infestations of aquatic weeds. No weed has been permanently eliminated from the pond.

In order to study the control of an emersed aquatic plant, the cattails (*Typha latifolia*) in Allerton Lake, a 14.5 acre lake also in Allerton Park, were chosen. Elimination of this weed was accomplished in two years using the herbicides dalapon and aminotriazole. This lake has been relatively free of cattails since 1962, except in one area where cattails were allowed to grow to prevent erosion of a bank. Similar

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eradication of cattails was successful in two other bodies of water.

Studies of the control of leafy pondweed, *Potomageton foliosus*, in Whetzel Pond near Mahomet, Illinois, since 1963 parallel the control of curlyleaf pondweed in Mansion Pond. The leafy pondweed has been under control since 1964, but continued efforts are needed to prevent spread of this weed.

An attempt was also made to eliminate duckweed, *Lemna minor*. Again, although the weed was not eradicated, the surface of the water was kept open and relatively free of duckweed during the growing season by judiciously applying herbicides.

From these studies Hiltibran believes that a program of aquatic weed control can be undertaken for the control of most aquatic weeds in ponds and lakes. Some of these can be virtually eliminated, but others will need a sustained program to maintain control just as a gardener must make judicious use of his hoe.

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A Helping Hand for Prairie Chickens

One-hundred years ago the Illinois prairie was a patchwork of grasslands, sloughs, and small farms, and our native prairie pinnated grouse, or prairie chickens as they are more commonly called, numbered in the millions. This abundance, however, was doomed by a growing nation's demand for food and expanding agricultural technology. With few exceptions, each recent spring has seen fewer cocks return to their ancestral booming grounds to strut and dance, to "boom" and mate. Prairie chicken populations were declining a rather consistent 20 percent per year in the early 1960s.

In 1969 and 1970, however, something different happened with the prairie chicken flock near Bogota in Jasper County. Where there had been 37 cocks on the booming grounds in 1968, biologists found 51 in 1969 and 108 in 1970. Survey biologist R. W. Westemeier found in the research he is currently directing in cooperation with the Illinois Department of Conservation that another successful nesting season is in progress and another increase in the number of birds on the booming grounds at Bogota in the spring of 1971 can be expected.

The key to saving the prairie chicken in Illinois is acquisition of suitable sanctuaries and development and maintenance of safe nesting cover on those sanctuaries. The success at Bogota demonstrates a prime example of a successful, cooperative effort between state agencies and groups of concerned citizens to save a segment of our wildlife heritage.

By the mid-fifties continuing studies by biologists of the Survey and the Department of Conservation showed that the prairie chicken was a critically endangered species in Illinois. In September 1959, the Prairie Chicken Foundation of Illinois, a private citizens' group was organized "to preserve and perpetuate the prairie chicken." This group has since acquired 5 nesting sanctuaries totaling 297 acres. By January 1965, it was apparent that prairie chicken numbers were still declining rapidly and that more sanctuaries were needed immediately if the prairie chicken was to be saved. At this time officers of the Illinois Chapter of The Nature Conservancy, a second citizens' group, formed a special "Prairie Grouse Committee." To

Prairie chicken cocks fighting over territorial boundaries on booming ground near Bogota. (Photo by Survey photographer Wilmer Zehr.)

date, the Prairie Grouse Committee has also acquired 5 sanctuaries near Bogota totaling 390 acres and has recently expanded its program to acquire 3 additional sanctuaries totaling 420 acres near Kinmundy in Marion County.

The role of the Natural History Survey has been to conduct research on the status, management, and ecology of the remnant flocks of prairie chickens. On the basis of this knowledge, Survey ecologists have proceeded to advise the private groups on acquisition and management of sanctuaries to provide optimum habitat. Biologists of the Department of Conservation have also contributed materially to sanctuary management. The Department has provided funds for short-term leases to provide emergency nesting cover and for support of research on prairie chickens by the Survey. Thus, there is now a well-coordinated program involving several state agencies and private groups for saving the prairie chicken in Illinois and restoring some native prairie in the state.

The long-range goals of the prairie chicken studies go beyond saving of this species. They include reestablishment and preservation of prairie plants as well as animals and the creation of a natural community which the people of Illinois can study and enjoy for many years to come.

Methoxychlor vs. DDT

Methoxychlor is a chlorinated hydrocarbon insecticide which is safe to warm-blooded animals, but is closely related to DDT. Survey scientists have been interested in methoxychlor because it is the currently recommended replacement for DDT in controlling the beetles which transmit the Dutch elm disease fungus. Much of the spraying for this disease is done in the municipalities on the periphery of Lake Michigan and it is possible that methoxychlor could enter the lake as well as its fresh water tributaries.

During the past year, a Survey team composed of aquatic biologist W. F. Childers and entomologists W. N. Bruce, K. S. Park, and Keturah Reinbold, have been investigating the fate of methoxychlor and other pesticides in water. They found that methoxychlor itself is three to four times less toxic to fish than DDT, depending on the species of fish. Although DDT is biodegradable over a period of time, the degradation products are also toxic and are very similar to the parent compound. Methoxychlor, on the other hand, is readily degraded into compounds which are conjugated and rapidly excreted by animals. Fish can absorb methoxychlor directly from water, but the compound is not stored and is readily excreted as a nontoxic metabolite. Degradation and excretion begin almost immediately, with almost total excretion within 100 hours. Methoxychlor can be transferred from water to small aquatic organisms and then to fish, but the process of degradation and excretion appears to be the same whether dealing with an individual animal or a group of animals composing a food chain. DDT, on the other hand, is concentrated in animal fat as the toxic compounds DDT and DDE.

The Survey team found that methoxychlor and its principal metabolities will not concentrate in fishes nor is storage or magnification of these compounds in the aquatic system likely. Therefore, homeowners, municipalities, and others in Illinois can use methoxychlor safely without jeopardizing Lake Michigan or similar surface waters.

Vinca Blight

The use of ground-cover plants in landscape designs for home as well as industrial and municipal plantings has become quite popular in the past twenty years. One of the most highly regarded species for ground-cover plantings is *Vinca minor,* also called myrtle or periwinkle. In recent years, however, a disease known as vinca blight, or dieback, has appeared in plantings in Illinois and other states. The disease has become so severe in some plantings that many nurserymen and landscapers in Illinois are avoiding the use of vinca as a ground cover.

To find out what is causing the disease, why it has become so prevalent, and what might be done in regard to disease control, Survey technical assistant G. A. Paulson and Survey plant pathologist D. F. Scho-

Blighted shoots of *Vinca minor*. (Photo by D. F. Schoeneweiss.)

eneweiss recently initiated an intensive study of vinca blight. They found that the disease is present in practically all plantings of vinca in the state. Laboratory investigations proved that the disease is caused by a fungus which forms girdling lesions on the stems and runners of vinca, resulting in wilting and dieback.

Disease lesions appear on old runners and on new shoots in the spring. Symptoms disappear during the summer only to reappear as lesions on runners in the fall. This peculiar feature of the disease suggested that temperature and perhaps moisture play a significant role in disease development. Investigations under controlled temperature and moisture showed that low temperature and high soil moisture — conditions commonly occurring in Illinois in the spring and fall — favor disease development.

The fungus which causes vinca blight was first reported from Europe many years ago. It seems likely that the fungus was imported with vinca plants at some time in the past. Since the disease fungus has been found on vinca shipped into Illinois from growers in other states, the disease is probably being spread throughout vinca growing areas on shipments of plants.

The fact that the fungus can survive in the soil and on plant debris may make control of vinca blight difficult. Since lesions are formed at the soil line where it is difficult to get coverage with surface-active fungicides, the only practical chemical control, if any, may involve the use of systemic fungicides that are absorbed by the plant.

Vinca beds that are well established and are watered during dry periods appear to put on enough vigorous new growth that, even though the disease is present, the planting retains a dense, attractive appearance. By using mulches and proper watering and fertilization to manipulate the environment around vinca stems, it may be possible to maintain attractive ground beds of vinca in spite of vinca blight.

Pollution Indicators

Survey biologists have conducted investigations on the aquatic life in the Illinois River since around the turn of the century. Comparing records from these early studies with those of current investigations, scientists at the Survey found that changes in such things as the mussel and fish populations over the years serve as good indicators of the effects of domestic, industrial, and agricultural pollution on the ecology of the river. This type of information cannot be obtained by chemical and bacteriological studies of the river.

In 1921, the entire Illinois River from Hennepin to its mouth was considered one of the most productive commerical mussel rivers in America. At that time the mussel shells were used to make buttons. The use of plastic in the manufacture of buttons virtually eliminated the mussel fishery of the Midwest. During the past decade, however, Japan developed a new export market for Illinois shells by using shells from midwestern streams in their pearl-culture industry. With the development of this new market, mussel boats soon began to appear on the lower Illinois River from Beardstown to Grafton. The fishermen considered the remainder of the river dead for mussels.

In 1966, Survey aquatic biologist W. C. Starrett began a detailed study of Illinois River mussels and discovered a series of

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unfished mussel beds worthy of exploitation in the vicinity of Peoria. Commercial fishermen used these findings and in 1969 removed over 200,000 pounds of shells for the Japanese market. Although in 1912 the Peoria section was considered to have the most productive mussel beds in the river, pollution from upstream virtually eliminated the mussels from this section by 1930. The reestablishment of these beds by a few species of mussels indicated that some progress had been made during the past forty years on the treatment of wastes from the Chicago-Joliet section of the waterway.

Since 1950, Dr. Starrett has also collected 106 species of fish from the Illinois River. Their abundance and distribution varies with the degree of pollution. By 1917 pollution had killed the fishes in the entire upper river. Today, although there are a number of kinds of fish in this section, the population is predominantly carp and goldfish. A comparison of modern records with those made in 1908 reveals that about fifteen species of fishes have been eliminated from the river by pollution. The middle and lower river now support only a small commercial fishery as compared with the large fishery existing at the turn of the century.

The species of mussels and fishes now living in the Illinois River have evidently developed some tolerance to pollution. Detailed bioassay studies are needed to accompany the Survey's field studies in order to determine the specific pollutants now limiting the abundance of such desirable commerical and sport fishes as channel catfish and largemouth bass. Such studies could furnish important guidelines for engineers and industrial planners involved in the building of new waste-treatment plants or the improvement of existing plants along the river.

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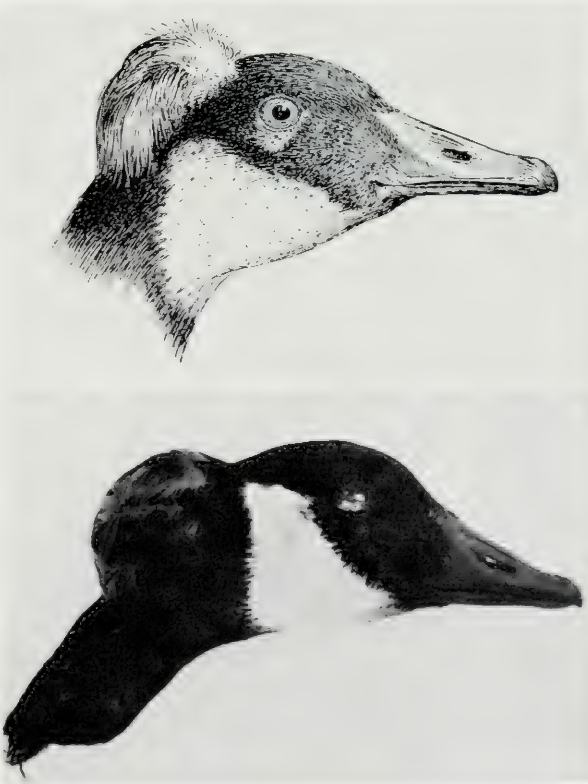
Once Upon a Mutation

Many decades ago a pair of Canada geese nesting somewhere in the North raised three goslings. We cannot claim royal blood for the parents, but it turned out that as the goslings matured, all developed head crests. It must be conceded that these ornaments scarcely made them more fortunate than their brethren; all three fell to hunters' guns at Pea Island, North Carolina. Such an incident was reported in 1913 by the late Dr. John C. Phillips, a Massachusetts physician and world authority on waterfowl in a brief article in *Auk.*

Since that time, despite decades of intense studies of Canada geese from coast to coast, no similar geese have been reported verbally or described in the technical journals. This July, wildlife specialist Harold C. Hanson of the Survey was able to visit briefly the Belcher Islands as a guest of a field party of the Minister of the Ontario Department of Lands and Forests, the Hon. Rene Brunelle. While there he obtained two specimens of Canada geese that clearly revealed what had been anticipated, that a distinctive, undescribed race, smaller than those breeding on the mainland, nested on these islands. However, of more immediate interest was the head of a Canada goose given to Hanson by the local administrator for the Canada Department of Indian Affairs and Northern Development. This head immediately recalled the Phillips' report of crested Canada geese cited by Hanson in a 1950 summary of aberrant plumages in Canada geese. After more than fifty years this mutational novelty had again made its appearance.



Crested Canada geese. The upper picture is a reproduction of the drawing by Dr. John C. Phillips published in *Auk* in 1913. The lower one is a photograph of the specimen obtained in 1970 by Harold Hanson. (Photo by Survey photographer Wilmer Zehr.)

Phillips implies that the crest is caused by a gene that exhibits imperfect dominance; it would seem more likely that it is the result of a rare recessive gene and is exhibited in the offspring only when both parents carry the gene. The chance of pairing by such rare genotypes is indeed small. Yet, this mutation must lurk in the background of the gene pool of many waterfowl. Crests or crestlike head plumes are possessed by a number of species of wild ducks and are characteristic of several kinds of domestic geese.

Raising Fishes in Cages

The ancient, Oriental art of culturing fish in cages is receiving some interesting applications in America. The earliest recorded use of fish cages seems to have been described for the streams of Cambodia, Japan and Indonesia. In Cambodia the cages were floated and food was administered daily to dense cultures of a highly favored catfishlike species belonging to the genus *Pangasius*. In some parts of Indonesia, the cages were weighted to the bottom of the streams, where the fish, principally carp, fed largely upon foods carried by the stream. In some highly polluted Indonesian streams, extremely high and efficient production of carp has been possible where the fish feed abundantly upon garbage and night soil that the villagers routinely dump into these streams. There is reason to suspect that this form of culture may have originated when an enterprising fish dealer observed that his unfed fish were gaining weight when simply stored alive in a cage submerged in the sewage stream which flowed by his market.

The first large-scale exploitation of the cage technique was probably made by the Japanese when in 1951 they began intensive experimentation with the production of carp in cages floated in freshwater lakes and shortly thereafter began to raise various species of marine fishes in cages floated in their great inland sea. The Russians acknowledged the work by the Japanese but claim that they were making extensive use of cages as early as 1940. More recent Russian work has dealt with the use of cages to exploit waters heated by the cooling of power stations in areas where the normal growing season was too short for efficient carp production.

The first known use of cages in this country seems to have been made by researchers at Auburn University for the high-density culture of channel catfish in cages floated in ponds. Additional studies involving catfish have been conducted by Southern Illinois University, by the State College of Arkansas, and by Survey biologist D. Homer Buck and co-workers at the Sam A. Parr Fisheries Center in Marion County, Illinois.

The present maximum production of channel catfish in both open pond culture and in cages floated in ponds appears to be about 2,000 pounds per acre. In both types of cultures the limitation apparently is due to an accumulation of metabolic wastes. Production can be increased by the use of a filtration system capable of eliminating the offending metabolites, or by the circulation of fresh water through the ponds.

Costs are higher for producing catfish in cages than in open ponds because of the cost of the cage and the more complete food required. Catfish free in ponds supplement their nutritionally incomplete pelleted food rations with natural foods that provide important vitamins and other nutrients. There are, however, a number of potential advantages to the use of cages. Caged fishes may be cultured in waters that might otherwise be unusable. They permit a quick inventory of the fishes, an efficient method of harvest, easy observation of feeding activity, more efficient use of food, easy health inspection of the fishes, and they do not eliminate preexisting cultures of sport fishes.

Studies in Illinois indicate that size and shape of the cages do not appear important, and we know of one Illinois farmer who has a successful operation utilizing the perforated drums discarded from worn-out washing machines. There seems to be no advantage, however, in using a cage deeper than three feet, and it is important that the cage bottom be at least one foot above the pond bottom.

In the present studies we are measuring

Male (above) and female dusky darters showing mating patterns. (Drawing by Mrs. Alice Prickett.)

the costs and efficiency with which catfish can be produced in cages floating in ponds and in larger reservoirs containing preexisting fish populations. In other work we have used cages to successfully grow both largemouth bass and rainbow trout, and others have used cages to grow bluegills and hybrid sunfishes. At this time it seems clear that much important research remains to be done in this area and that the potential application of the cage culture technique appears to be tremendous.

Dusky Darter Data

To understand the relationship between an organism and the environment, it is necessary to know the ecological requirements of the organism throughout its entire life. For this reason Survey scientists conduct detailed life-history studies on various kinds of Illinois plants and animals. These studies probe almost every conceivable facet of the life of the organism in an attempt to assemble all information possible on the ecology of the species. Each investigation thus contributes to our understanding of the total environment.

An illustration is a paper just published as Natural History Survey Biological Notes No. 69 entitled "The life history of the dusky darter, *Percina sciera,* in the Embarras River, Illinois" by Survey ichthyologists L. M. Page and P. W. Smith. The dusky darter is one of several small fishes that serves as an indicator of high water quality because it cannot exist in polluted streams and those in which natural habitats have been extensively modified.

One of three ecological investigations carried on simultaneously in the Embarras River near Greenup, this two-year study of the dusky darter summarizes information on habitat preference, behavior, reproduction, development, growth, longevity, population density, associated species, migrations, food habits, and such interactions with other animals as competition, predation, parasitism, and hybridization.

In the relatively undisturbed and unpolluted Embarras River, the dusky darter is abundant. Authors Page and Smith conclude that population size is primarily controlled by fluctuations in water levels, particularly flooding during the spawning period. They found no evidence of predation on the dusky darter by large fishes

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such as bass, although the darters are probably fed upon occasionally by fish, water birds, and snakes. The authors noted that competition for food and for space on the spawning grounds with another fish, the slenderhead darter, was also possible, and a detailed life-history study of the slenderhead darter is underway. The greatest threat to both species — and all fishes that occupy flowing water — is the construction of dams, which eliminate the riffle habitat.

Copies of this sixteen-page life-history study are available upon request to the Natural History Survey.

Insecticides in Pheasant Eggs

A widespread and pervasive contamination of the environment inhabited by pheasants in East-Central Illinois by several persistent chlorinated hydrocarbon insecticides is suggested by studies of residues found in pheasant eggs, according to Survey biologists R. E. Greenberg and W. R. Edwards. Residues of both aldrin and DDT were found in 119 out of 120 eggs collected during June of 1966. In addition, heptachlor residues were observed in 61 out of 120 eggs. The eggs came from 21 different clutches (nests) from four counties.

Although average residue levels for individual insecticides appeared within the safe range, analysis revealed high variability both among eggs and among clutches of eggs. Some eggs showed fairly high levels of aldrin residues, and there was an apparent overlap in the distribution of observed values with levels observed in eggs of penned pheasants fed two and four milligrams of dieldrin per week by investigators in South Dakota. The offspring of these penned hens did not reproduce normally.

Considering (1) the extent of contamination evidenced by the sample, (2) the variety of toxicants involved and potentially involved, (3) the high variability of the residue levels observed, (4) the effects of these compounds that persist into the second generation, and (5) the effects of chemicals in combination, which can be more toxic than each alone, it is obvious that one cannot be complacent about average residue levels of individual insecticides. Our concern must be for the total contamination of the environment and the community it is expected to support.

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Mallard Navigation

As the sun dropped below the horizon on a prairie lake near the Alberta-Saskatchewan border, a flock of mallard ducks sprang into the air, climbed into the darkening sky, and headed southward. Amid tumultuous quacking, flock after flock followed the forerunners, some heading south, some southwest, most heading southeastward. The fall migration had begun.

Many flocks alighted on marshes familiar to their leaders by sunrise and remained for three to five weeks before proceeding south. Others whose marshes were farther away continued to fly after sunrise to reach their destination or paused at a lake during the day and resumed their journey the following night. Most of the mallard flocks made two stops along their migration route before settling down for the winter in their southern homes.

The means by which the mallards found their way back to familiar marshes used during the previous migration is part mystery, part known fact. Following many years of study, observation, and experimentation, Survey wildlife specialist Frank C. Bellrose recently summarized the known information on mallard migration and came up with the following story.

The evidence seems clear that mallards and other waterfowl use the sun and stars, when visible, to determine direction. They make adjustments for the continual movement of these bodies across the sky by using an internal "clock." Duck hunters in the 1940s, when duck hunting ended at 4:00 p.m., knew what they were talking about when they claimed that mallards wore watches. Almost precisely at 4:00 p.m. mallards start winging their way from resting grounds to grain fields and other feeding areas. Observations over many years have also shown that mallards regularly range up to thirty miles to feeding sites around their migratory and winter homes. Since they usually spend several weeks in each area, they become familiar with the landscape for many miles and this knowledge enables them to correct for navigational errors during migration. Bellrose's observations, supported by data collected on banded birds, confirm that mallards frequently overfly their destinations on overcast nights but reorient themselves from landmarks during the day and return to their home marshes the next evening.

Large lakes and rivers apparently provide mallards and other waterfowl with cues that are used to make major changes in direction. Banding data as well as ob-

Migrating mallards. (Drawing by Robert H. Cary.)

servation from aircraft show that flocks of mallards change from a southeasterly to a southernly direction upon reaching the Mississippi and Illinois River valleys. This change occurs day or night if the water-courses are visible to the birds.

According to Bellrose, the mechanism or orientation of mallards and other birds during migration involves more than familiar landscape features and guidance by sun, moon, and stars. Radar surveillance of migrating waterfowl has shown that flocks often fly in an oriented manner even under overcast skies at night when neither landscape nor moon and stars are clearly visible. Bellrose believes that birds are able to use the wind to guide themselves, particularly aloft where wind direction is fairly constant. In addition, experiments in Germany and the United States indicate that birds are able to detect the earth's magnetic field.

How and when wind and magnetic field function in bird-guidance systems, and what sensory devices birds possess to detect and evaluate the different types of navigational information remain mysteries which will require much further study to solve.

Insect Defenses in Primitive Plants

The ability of many plant species to avoid insect injury has aroused the curiosity of entomologists and other scientists for many years. Lichens, ferns, and horsetails are among those plants which are especially resistant to insect attack and are fed upon by only a few insect species with highly restricted food habits. These plants are members of a primitive group and were abundant on earth long before plant-feeding insects appeared. The species which have survived to the present day may have developed, through coexistence with insects from their first appearance, a chemical makeup which helped them survive the onslaught of plant-feeding insects.

In recent years increasing research on insect–plant relationships is enabling scientists to learn more about the chemicals in plants which influence the behavior and growth of insects. In 1969, Survey entomologists W. L. Howe and Eva Zdarek began a study to determine how three of our destructive crop insects — the corn earworm, the tobacco budworm, and the fall armyworm — respond when fed small amounts of primitive plants such as ferns in otherwise nutritionally adequate diets. The results were quite surprising. For example, one part of freeze-dried leaves of the hairy lip fern, common to Southern Illinois, in 10,000 parts of diet almost completely blocked growth of fall armyworm larvae after the first molt. These tiny worms, after consuming a small amount of the diet, suddenly stopped growing and died while their counterparts on the diet without the fern additive grew into healthy specimens weighing several hundred milligrams. Strangely enough, increasing the fern concentration one hundred times did not appreciably increase its adverse effect on the larvae.

Adding portions of other primitive plant species to the diet produced abnormalities such as the inability of larvae to completely shed their outer skin during molt, feeding suppression, diet rejection, abnormal pupation, and formation of deformed adults. Acute toxicity was seldom observed; in fact, larvae unable to continue growth on the adulterated diet were often able to recover when transferred to the standard diet.

These primitive plants contain a host of varied chemicals and it is evident that some are specific in altering insect metabolism. Entomologists working in cooperation with chemists have found that ferns are a particularly rich source of hormonally active substances that regulate growth and molting in insects. The methods employed here are only the first step in a painstakingly slow and difficult process in determining nature's own chemical defenses against insect attack. Hopefully such chemicals, when identified, might be synthesized or even improved for use against crop-destroying insects without endangering man or his environment.

Cantankerous Disease

Of the several methods used to combat tree diseases, two of the most common are the application of fungicide sprays and the selection of disease-resistant plants. In order to keep environmental contamination at a minimum, Survey plant pathologists

Leaf blotch on horsechestnut. (Photo by Dr. Dan Neely.)

attempt to develop control recommendations for tree diseases which require the least possible application of fungicide chemicals. To achieve this goal, they place great emphasis on studies of disease resistance among the species and varieties of trees.

In 1963, Survey plant pathologists Dan Neely and E. B. Himelick published a list of species and varieties of *Aesculus* (buckeye and horsechestnut) and rated their relative susceptibility to the fungus disease known as leaf blotch. Only five out of the thirty-six varieties observed at that time at the Morton Arboretum in Lisle, where most of the species and varieties of *Aesculus* are present, exhibited resistance to the disease. Studies conducted in 1970 confirmed these observations and added one more resistant and four more susceptible varieties to the list. The small number of species and varieties in this genus showing disease resistance limits the selection of trees with horticultural characteristics that nurserymen, landscapers, and homeowners consider desirable.

In addition to disease resistance studies, Dr. Neely and Dr. Himelick set up field tests at the Morton Arboretum to determine which commercial fungicides would protect susceptible buckeye and horsechestnut varieties against infection by the leaf blotch fungus. Tests conducted in 1960, 1961, and 1962 indicated that the disease could be controlled with a single application of any of three fungicides if applied in May when new shoots were seven to ten inches long. In 1969 and 1970, however, when they set up additional tests comparing the same fungicides with several of the newer fungicides, none of the materials provided satisfactory disease control. The leaves of treated plants had as many disease spots as those of untreated plants.

This presents quite a problem for the Survey pathologists. Most of the desirable species and varieties of *Aesculus* are susceptible to leaf blotch and the current spray recommendations may not give satisfactory control of this disease. Additional information must be obtained on the various factors involved in the spread and occurrence of the disease in Illinois before effective control measures can be formulated. In the meantime, since leaf blotch causes considerable damage practically every year, the value of *Aesculus* varieties as landscape plants is greatly reduced.

Soybean Insect Information Center

Next to laboratory research, literature review is perhaps the most important part of any scientific research program. Without a thorough knowledge of what has been done previously in a particular area, much valuable time can be wasted by duplicating what has already been done or by heading off in an unfruitful direction.

In conjunction with the research on soybean insects which is currently under way in the Survey's Economic Entomology Section, a Soybean Insect Research and Information Center has been established. It is intended to provide researchers with access to published information on a worldwide scale by means of a collection of citations and abstracts to relevant articles dealing with insects which feed upon soybeans. Papers on all aspects of the insects, including collecting, rearing, physiology, and taxonomy, are included.

Complete citations of relevant articles from researchers who work on the insects, from previously discovered articles, and from current journals are collected by Survey technical assistant Martha P. Nich-

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ols. The searching out and verifying of article citations is in the hands of technical assistant Nancy DeWitt. Citations and abstracts are entered on edge-notched cards and subject headings are assigned for retrieval purposes.

Although the system, begun in 1969, was originally intended to be solely a coded card system, more than 5,000 citations have been gathered since then, dealing with over 640 different insect species. The size of the collection lead to the utilization this summer of one of the University of Illinois' IBM computers for more efficient information retrieval. The Survey now has a program designed to retrieve citations in its master file by particular authors or by particular subjects or combination of subjects. In addition, the Survey has retained the edge-notched cards for quick searching, as well as a manual author card file.

The Center also plans to publish a series of bibliographies on insects which feed on soybeans. Currently, Survey entomologist Marcos Kogan is working with Miss Nichols on the first of these, which will deal with the Mexican bean beetle.

Although the Center is not yet completely operable, the Survey, by spring 1971, hopes to be able to provide information rapidly to its own soybean researchers and to others throughout the world who might benefit. Bibliographies in the form of computer print-out and machine copies of abstracts will eventually be available on request.

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Hawthorn Mealybug

Of the approximately ninety thousand insects in North America, many thousands are known only by name. Little or nothing is known about their life style. Entomologists generally take the opportunity to study the life cycle and habits of one of these insects whenever that opportunity presents itself. Thus, when the hawthorn mealybug, *Phenacoccus dearnessi,* was found to be abundant on certain hawthorns *(Crataegus crusgalli)* and cotoneaster *(Cotoneaster apiculata)* in Illinois, Survey entomologist J. E. Appleby began a thorough study of its life cycle and of its parasites and predators.

The hawthorn mealybug overwinters in Illinois in the second stage, or instar, on the trunks or main stems of the trees or shrubs, the males enclosed in a cocoon and the females covered by a light mealy secretion. The females emerge near the end of April, shed the second-instar skin, migrate to the outer branches and feed at the bases of leaf bud scales. After a week or ten days, the third-instar females migrate back to the trunk area, shed the third-instar skin and mate with the males. The fourth-stage females then migrate back to the small branches and settle down to feed and lay eggs (up to 1,284 were observed produced by one female).

The eggs hatch within fifteen or twenty minutes and the first-instar young feed on the undersides of leaves for a few days. They then migrate to beneath loose bark where they remain until late August. They then molt and the second-stage young move back to feed on the undersides of leaves and then move back to the trunk area to overwinter.

The males overwintering in cocoons behave somewhat differently. In spring they molt three times while still in the cocoon and the small, slender, winged adult males emerge during the first week of May. They seek out females, mate and die within a few days.

From this life cycle it is clear that if this pest of ornamental shrubs becomes

Phenacoccus dearnessi on twig of hawthorn. Two adult females and several first-instar young (crawlers) can be seen. (Photo by Survey photographer Wilmer Zehr.)

abundant, one cannot spray insecticides at any time to obtain the best control. The insect is obviously more vulnerable at certain periods of its life cycle than at others, and it is also obvious that control should be exercized during vulnerable periods early in the season to avoid economic damage to the plants. Adequate control measures for noxious insects frequently await just such studies as this one. Dr. Appleby has reported on this study at meetings of the Entomological Society of America and the study now awaits publication.

Illinois Birds

It may surprise many people to learn that comparatively little is known about Illinois birds and especially scant quantitative information is available. Understanding of bird populations, their seasonal and yearly fluctuations and migrations is little advanced over what it was about a century ago when Robert Ridgway first started his studies of Illinois birds.

Accelerating changes in the land have brought us to a potentially precarious ecological state with which we are ill-prepared to deal or even to assess. We need to know more than simply what animals and plants occur in Illinois. We need answers to many questions — questions about the distribution of populations, their reproductive potentials and food habits, their energy and habitat requirements, their migration routes, and ultimately their ecological relationships to every other part of the environment. The answers will come for the birds of Illinois through the efforts of many dedicated students of all ages throughout the state.

The Survey has published the first part of a series of reports on Illinois Birds (Biological Note No. 68, September 1970). This first part deals with the family Mimidae (mocking birds, catbirds and thrashers) and was prepared by Richard R. Graber, Jean W. Graber, and Ethelyn Kirk. This paper, like those to follow, attempts to summarize what has been recorded about Illinois birds. The series includes exhaustive information culled from the literature as well as significant studies on migrations, population sizes, breeding, overwintering, and food habits discovered through the research efforts of the authors. To illustrate the magnitude of the literature search, the authors perused about fifteen-hundred references for the family Mimidae alone.

The paper is well-illustrated with photographs of birds and nests, and with maps of distributions and migration routes. Much of the quantitative data is summarized in graphs so as to be readily assimilated. Copies of *Illinois Birds: Mimidae* are available upon request.

Sunfish Isozymes

During the past fourteen years a rather comprehensive study of the genetics of sunfishes has been conducted at the Illinois Natural History Survey. Many of the twenty-seven different species of sunfishes have been successfully hybridized. The three primary objectives of this study are (1) to produce hybrid sunfishes which are superior to their parent species in size, rate of growth, hook-and-line success, and flavor and texture of meat, (2) to learn more about the genetics of the parent species, and (3) to gain some understanding of the evolution of this family of fishes.

The identification of sunfish species and hybrids has, in the past, been based almost entirely on morphological differences (differences in body shape or form). The ranges of variation of most key morphological characteristics of closely related species overlap one another. Consequently, it is necessary to examine a fairly large number of characters before an individual can be positively identified. This is often a tedious and time-consuming task.

All organisms contain chemical compounds which can be divided into four main groups: proteins, nucleic acids, carbohydrates, and fats. During the past ten years methods have been devised for detecting and identifying many proteins. One large group of proteins is called enzymes. Enzymes are responsible for controlling the rates of chemical reactions within the bodies of all organisms. Some enzymes have more than one molecular form. The different molecular forms of such an enzyme are called isozymes.

A joint study, headed by Survey aquatic

On the left are three sunfishes — above is the largemouth bass, below is the smallmouth bass, and in the middle is the F_1 hybrid. On the right is illustrated the electrophoresis analysis of the isozymes of the three fishes. (Photo by Survey photographer Wilmer Zehr.)

biologist William Childers and University of Illinois zoologist G. S. Whitt, has been started to investigate the isozymes of sunfishes. By the use of electrophoresis (the separation of molecules with different electrical charges in an electric field), the group has discovered that all twelve species of sunfishes examined so far have a similar spectrum of isozyme patterns. As one would suspect, the isozyme patterns of closely related species are only slightly different while there are much greater differences between distantly related species. Nevertheless, each of the twelve species and hybrids of these species can be readily distinguished from all of the others on the basis of isozyme differences. For example, as shown in the figure, the lactate dehydrogenase (LDH) E_4 isozymes of largemouth bass, *Micropterus salmoides,* and smallmouth bass, *M. dolomieui*, are different, and the F_1 hybrid of these two species contains the characters of both parent species. One-fourth of the F_2 hybrids, produced by mating an F_1 hybrid with another F_1 hybrid, were identical to smallmouth, one-half were identical to the F_1 hybrid, and one-fourth were identical to the largemouth. This study furnishes proof that in these two species of bass the LDH E_4 isozyme is under the control of a single gene with two alleles.

There are a number of advantages in using isozymes for identifying fishes. First of all, unlike morphological characters, the environment has little effect upon them. Pure species and hybrids can be accurately identified in a very short time. Only a very small piece of tissue is needed, so it is unnecessary to kill the fish.

Dr. Childers and Dr. Whitt plan on studying isozymes of all twenty-seven species of sunfishes and as many of their hybrids as possible. When the study is complete it should be possible to establish definite evolutionary relationships between these species.

Winter Survival

How do insects overwinter? With many insects the answers to this question remain unknown, even for some well-known pest species.

Beginning this November, the search for overwintering sites, or the hibernacula, of insects will be continued. Leaves in the forest or along fence rows, bark of dead branches, and other debris will be collected and searched to learn what adult insects take winter shelter in these habitats. The Survey maintains racks of Berlese funnels,

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funnels warmed by steam heat into which debris is placed to force insects out into collecting jars. These funnels allow us to monitor the overwintering populations of chinch bugs and other pests, and now are being used to locate more minute forms such as mites, thrips, and symphylids.

One elusive insect, the soybean thrips, so common in Illinois in summer, seems to abruptly disappear in winter. In October many adults were still being encountered on vegetation, but we expect that these will be gone after the first heavy frost. Do they perish in winter and reinvade Illinois from the South every spring? Survey graduate research assistant Thomas C. Vance, who has been studying these thrips under the direction of Lewis J. Stannard, has arranged a winter program of search for these thrips around local soybean fields, examining all the debris and even soil that might act as a refugium for this pest. His findings will give us either an answer or, at least, clues for further research. All these investigations are part of a larger project on soybean insects, coordinated by the entomologists of the Survey and supported by institutions in other states and countries.

The overwintering habits of soybean insects is only one phase of our studies, but it could be an important one for control measures as winter is a time of cold stress. Knowledge of winter habits of the insects together with climatological data could make possible predictions of economic outbreaks during the next growing season.

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DECEMBER 1970. NO. 98

Yuletide Fungus

Finding a research article appropriate for the December issue of the *Survey Reports* is not an easy task. This year the credit goes to Survey mycologist Leland Crane for a report from the microscopic world of the fungi.

For the past three years Dr. Crane has been engaged in a long-range study of the kinds, relative abundance, and distribution of fungi in Illinois waters. In the course of this study an extensive year-round sampling program is in progress on the Mississippi River and on three cypress swamps in Southern Illinois.

While studying the fungi in the Elvira, Illinois, cypress swamp northwest of Vienna, Dr. Crane found a peculiar fungus on the decaying fruit of black walnut that had not been reported previously in Illinois. The outstanding feature of this fungus, technically known as *Dendrosporium lobatum,* is the reproductive spores which are wedge-shaped with deep constrictions and resemble the common illustrations of Christmas trees. This represents only one of the many diverse spore types commonly encountered in fungi from aquatic and terrestrial environments. In water these fungi have been found on a diversity of materials such as wood, leaves, fruit, paper, strings, clothes, glass, and plastic.

How these coexist in the aquatic community still remains virtually unknown. Only within the past few years have mycologists seriously directed their attention toward aquatic fungal populations and the role these organisms play in the complex, often delicately balanced, aquatic environment.

Composite photomicrograph of the fungus *Dendrosporium lobatum* showing fungal strands and Christmas-tree-shaped spores. Each spore measures about 0.001 of an inch. (Photo after *Mycologia,* 1936.)

No Fear of Mercury in Illinois Pheasants

Mercury contamination has been the subject of considerable publicity in recent months. Pheasants and Hungarian partridge in Alberta, Canada, and in Montana have been found to contain potentially dangerous levels of mercury, as have fish in certain lakes and rivers in North America. The Alberta government, being concerned about public health, closed the hunting seasons on pheasants and partridge in that province in 1969. The U.S. Food and Drug Administration recently established a mercury tolerance level of one-half of one part per million as a temporary guideline for fish, but tolerance levels have not been set for game birds, poultry, or other foods.

Any fears Illinois hunters might have about the pheasants they bag being contaminated with dangerous levels of mercury can be put aside, according to a report released by Survey wildlife specialist William L. Anderson. Our pheasants appear to be relatively free of this highly poisonous heavy metal.

Anderson, working in cooperation with Stewart Laboratories, Inc., Knoxville, Tennessee, analyzed muscle, liver, kidney, and brain tissues for mercury from each of twenty pheasants that were collected during August 1970. The birds were taken in east-central Illinois, the state's prime pheasant range. Although mercury was detected in one or more tissues of 85 percent of the pheasants, the concentrations were seldom greater than one-tenth of one part per million. Only 15 percent of the birds had detectable levels of mercury (two-hundredths of a part per million or greater) in breast muscle and only 25 percent had detectable levels in leg muscle. Because mercury occurs naturally in the environment, small amounts of the metal might be expected to be present in the pheasants.

Pheasants and partridge in Alberta and Montana apparently became contaminated with mercury by eating seed grain treated with organic mercury fungicides. In Illinois, however, mercury fungicides are used sparingly to treat seed grain of wheat, oats, barley, and rye, according to information obtained from University of Illinois extension pathologist Malcolm D. Shurtleff. The use of mercury compounds for this purpose has decreased 90 percent since 1963. Corn and soybeans, the principal crops throughout Illinois' pheasant range, are never treated with mercury fungicides, Dr. Shurtleff said. Thus, it is unlikely that Illinois pheasants or other game birds will become dangerously contaminated with mercury.

Healing of Wounds on Trees

Historical writings show that man has been concerned with wounds on trees for over four thousand years. Treating of tree wounds, however, is still more of an art than a science. Few practices used commercially in treating wounds originated from detailed observation or experimentation.

To obtain some sound, scientific information on this subject, Survey plant pathologist Dan Neely initiated a study in 1967 on the healing of wounds on white ash, honey locust, and pin oak at the Morton Arboretum, Lisle, Illinois. The purpose of the study was to compare the rate of healing of wounds of different shape, width, facing direction, and height, as well as the influence of the season of wounding and stub length. In addition, the relative merits of various wound dressings on healing were studied, along with the relationship between tree vigor and rate of healing.

Test trees were spaced fifteen to twenty feet apart and were fifteen to twenty feet tall when the study began in 1967. Most of the wounds were made in 1967, with a few additional wounds made in 1968. The width of each wound was measured and recorded the day of wounding and the amount of healing was determined from measurements of width of wood remaining exposed in the autumns of 1967, 1968, and 1969. The trunk circumference of each wounded tree was measured at a marked point each year to determine growth rate or vigor.

From the results of this study, Dr. Neely was able to draw several interesting and useful conclusions. Trunk wounds heal primarily during the months of May, June, and July. Pruning wounds cut through the branch collar heal rapidly whereas pruning wounds leaving branch stubs heal very slowly. The rate of healing was not affected

Completely healed elliptical wound on white ash. (Photo by Dr. Dan Neely.)

by the direction the wound faces or by the height of the wound on the trunk on vigorous trees or trees with low crowns. Wound healing rate increased in years when growth rate increased and there was no appreciable difference in rate of healing among trees of different species. According to Dr. Neely, the most important dimension of a tree wound is width. The narrower the wound, the more rapidly it heals. Applying wound dressings of various types did not increase the rate of healing.

The information obtained should be of value in making intelligent recommendations for treating tree wounds. Detailed data from this study were published in the September 1970 issue of the *Journal of The American Society for Horticultural Science.*

Insect Disease Dilemma

To help keep pesticide applications at a minimum, scientists working on insect control are trying to make greater use of biological control factors such as predators and parasites of undesirable insects. Unfortunately, some of these organisms refuse to distinguish between useful and harmful insects.

For a number of years scientists at the Survey have been aware of a disease which affects the black blowfly, *Phormia regina,* and other calypterate flies in Illinois. This disease is caused by a tiny microsporidian known as *Octosporea muscaedomesticae.* It is transmitted orally by means of a tiny resistant spore. This spore produces an infectious form which invades and destroys the cytoplasm of the mid-gut epithelial cells of the flies. Most coleopterate flies are unwanted pests and the occurrence of such a disease in the natural populations of these flies is considered beneficial.

Survey insect pathologists J. V. Maddox and R. K. Sprinkel recently found that a variety of this pathogenic microsporidian also infects a group of beneficial insects, the Syrphid flies. The larvae of many Syrphid flies are predacious on aphids and are an important factor in the natural control of these insects.

In an area around Champaign, Illinois, almost 30 percent of the adults of the Syrphid fly *Mesograpta marginata* were infected with the microsporidian during the summer of 1969. Nearly 10 percent infection was found in another Syrphid fly,

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Allographta obliqua. The organism from the Syrphid flies will infect the black blowfly but the disease has slightly different characteristics from the one which occurs naturally in black blowfly populations.

Very little information is available on how this disease affects Syrphid fly populations but it undoubtedly suppresses these populations to some extent. Much research is needed in the area of biological control since insect diseases, like diseases of man, infect the good guys as well as the bad.

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NATURAL HISTORY SURVEY REPORTS

JANUARY [illegible]

Wintertime Culture of Trout

Waters in most small impoundments in Illinois are too warm for trout during summer months, but there is a period extending from November through March when water temperatures may be within the optimum range for rainbow trout. In the southern one-third of Illinois, during mild winters, ice cover on ponds or lakes may be limited to a few days or weeks, and much of the time when the ponds are open, trout will feed on fish pellets.

Last winter, as a continuation of experiments in the cage culture of fishes at the Sam A. Parr Cooperative Fisheries Research Center in Stephen A. Forbes State Park (Marion County), Survey aquatic biologists D. Homer Buck, Richard Baur, and Russell Rose decided to test the practicability of trout production in cages during winter months. The cages were 4 feet long by 4.5 feet wide by 4 feet deep, composed of one-half-inch mesh hardware cloth and floated on styrofoam to provide a water depth in the cage of about 3.3 feet. A plywood "feeding ring" was projected through the center of a plywood lid to a depth of about 12 inches below the water surface. The two cages used in this preliminary experiment were floated in a one-acre pond in a location where the water was six feet deep.

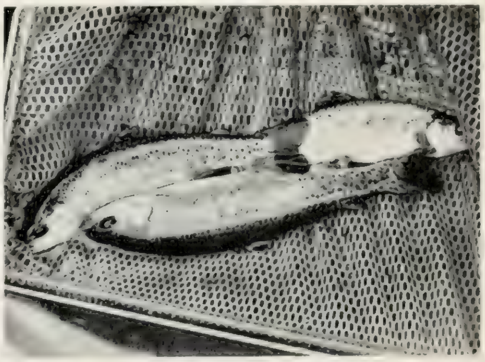
Trout for the experiment were furnished by the Missouri Department of Conservation. The cages were stocked with 412 trout each on February 17, 1970. The water had warmed to 41° F (5° C), and most of the ice was gone by February 19.

The trout were fed sparingly during the rest of February but began to feed well at the beginning of March. The beginning ration of pelleted trout food was 1.6 percent of the fish's body weight per day, but this amount was soon raised to 4.4 percent as the water temperature increased. However, feeding activity diminished sharply during recurring cold spells. The maximum feeding rate was 4.75 percent of the fish's body weight per day.

Conversion rates from March through April 13 averaged 2.32 pounds of feed for 1.00 pound of fish flesh gain, but the efficiency dropped after the water was warmed in late April and early May. These rates were all poorer than those obtained in tests in Missouri Fish Hatchery raceways which were 1.35 and 1.42 to 1.00.

Total mortality for the study was 34.5 percent. Trout that survived more than doubled their weight in a seventy-four-day feeding period and were large enough for the frying pan at the end of the experiment.

This year a similar experiment was started on November 10 and is still in progress. Over the first month of current



Rainbow trout at time of placement in cages. (Photo by George Bennett.)

tests, samples of sixty fishes from each of three cages showed a food conversion ratio of 1.30 to 1.00. This is a great improvement over last year's experiments.

Water temperatures between 52° and 62° F appear to be optimum for trout production, whereas about 60° F is the minimum for catfish. While the economic potential for the wintertime rearing of trout in cages in warm-water ponds might not justify a large investment, such an operation might successfully supplement catfish production. Following the harvest of catfish in October, the cages could be devoted to the rearing of trout for harvest in early May — the cages being in use year-round rather than in summer only.

Frog Spots

Anyone traveling from north to south in eastern North America and interested enough in frogs (such as a herpetologist or a ten-year-old boy) would notice that populations of these animals differ in pattern from place to place. Noting such variation in Illinois, Survey biologist P. W. Smith and R. T. Schaaf of the University of Illinois at Urbana-Champaign undertook a study of the geographic variation of the pickerel frog. Having collected specimens and borrowed all appropriate material available, they have analyzed variation trends in the species.

Frogs from northern areas were found typically to have a large dark spot on top of the snout, one on each eyelid, and two rows of large, squarish dark blotches down the back. However, frogs from the Atlantic and Gulf coastal plains usually lacked a snout spot and had fewer, smaller, and round spots on the head and body. Northern frogs also were found to have a glistening white throat and breast, but those from the coastal areas had dark flecks and markings on the undersides.

Schaaf and Smith then looked at other kinds of frogs and discovered that these same trends were paralleled in some other species. A study of where the frogs lived and their habits revealed plausible explanations for this pattern.

Frogs living north of the coastal plain area live in the clear cool water of lakes and streams; those on the coastal plain live in the warm, murky waters of cypress swamps and floodplain sloughs. Since the principal predators are fishes that see the frogs from beneath, the glistening white underside would be less conspicuous in clear water but the dark, mottled underside would less likely be seen in the darkly stained waters of the southern swamps. Thus, clarity of water seems to be the environmental factor which, through selective predation by fishes, controls the ventral pigmentation of pickerel frogs.

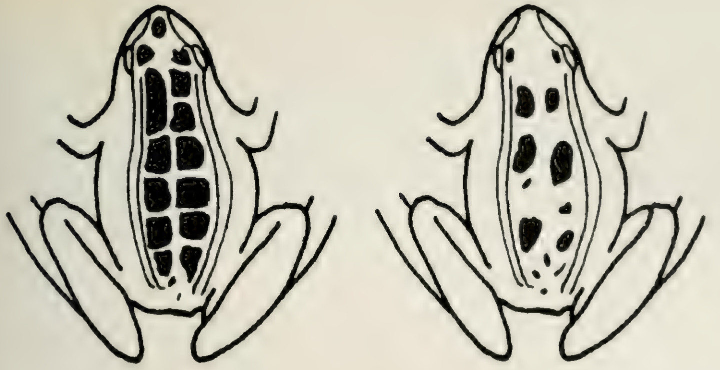
The dorsal color pattern seems to be related to the heat budget of these cold-blooded animals. A frog floating at the surface of the water has only his snout and eyelids above the water, and each of these has a large dark spot in the cooler northern climes. The large body blotches of the northern frogs more efficiently use the limited surface of the frog's body than the round spots of southern frogs. This mass of dark pigment can absorb considerable heat from the sun. Frogs living and breeding in the warm floodplain swamps of the coastal area have no need for such heat-gathering pigments and these are limited as described above. The authors believe that these features have become genetically fixed through natural selection.

For anyone interested in a more complete discussion of the variation in this species, reprints of the recently published "Geographic Variation in the Pickerel Frog" are available free upon request to the Survey.

Counting Cottontails

In order to determine long-term changes in rabbit abundance, Survey biologists — currently wildlifer G. B. Rose — have been conducting studies of numbers of rabbits on a one-hundred-acre study area, the 4-H camp area at Robert Allerton Park near Monticello, Illinois, each fall since 1956. Much of this area is in the process of changing from cultivated land to forest.

Rabbits are more readily trapped in the fall than at other times of year, and by fall the breeding season is over. They are captured in wooden live-traps, ear-tagged, tail-dyed, and released during ten-day



Representative dorsal patterns of pickerel frogs. Type at left from upland area (Jo Daviess County, Illinois); at right, from coastal plain (Alexander County, Illinois).

trapping periods at the beginning of each month from October through December. A drive is conducted through the area, with the aid of a class from the University of Illinois at Urbana-Champaign, to obtain an estimate of the ratio of marked to unmarked rabbits in the population, and thereby an estimate of the total number of cottontails on the study area. Other estimates are obtained from the trapping data, being based on frequency of capture.

From 1956 through 1961 the numbers of rabbits on the study area in the fall ranged from 2.4 rabbits per acre to 3.6 rabbits per acre, averaging around 3.0 rabbits per acre. From October 1961 to October 1962, however, the population dropped abruptly from 3.6 per acre in 1961 to 1.1 per acre in 1962. For the next four years, 1962 through 1965, the population density fluctuated between 0.9 and 1.5 cottontails per acre. Between fall 1965 and fall 1966, the density again increased, from 1.0 per acre in 1965 to 2.6 per acre in 1966. From 1966 through 1970, rabbit abundance has remained high, fluctuating between 1.7 rabbits per acre to 2.8 rabbits per acre, and averaging about 2.2 per acre.

Dr. James Bailey, formerly with the Survey, described apparent cyclic fluctuations in cottontail populations spanning periods of eight or more years in a large area of the eastern United States. The last period of general abundance was 1955–58 and was followed by a period of general scarcity from 1960 to 1965. The 1962 change from abundance to scarcity on the 4-H area lagged two years behind the regional change.

The data from the 4-H area do not indicate a smooth curve of change from abundance to scarcity to abundance again. Rather, they suggest fairly abrupt changes from periods of relative abundance to scarcity, and vice versa, and that those periods may then last from four to six years. The data further suggest that, within a given period of relative scarcity or abundance, year-to-year fluctuations may be considerable but not nearly as pronounced as the changes that initiated the respective high or low.

Although fifteen years of data are not enough to evaluate cyclic tendencies in cottontail populations, it appears that changes in abundance on the study area may be controlled by factors responsible for the eight- to eleven-year regional cyclic fluctuations, by factors responsible for year-to-year fluctuations, and by shifts in ecology in the area caused by changes from abandoned cropland to forest.

In a study of this nature it is risky to draw conclusions from so few years' data. Had the study been discontinued after six years, there would have been no indication that the fall population would drop greatly by the next year. Similarly, had the study been discontinued after ten years, it would have been impossible to predict that the population density would rise again by the next year. However, we now expect a continuation of the pattern of periodic highs and lows which will manifest a long-term decreasing trend in rabbit abundance unless there is a dramatic shift in the use of the area.

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FEBRUARY 1971, NO [illegible]

Centennial Issue of Survey Reports

The one hundredth issue of *Illinois Natural History Survey Reports* is a tribute to the dedication and concern of Survey officials and scientists regarding the natural resources of the state. Since many of the Survey's research and service activities are supported by state legislative appropriations, we believe our citizens are entitled to know what the Survey does with these funds and why. In addition, we feel it is important that Illinoisians know about basic research activities which the Survey undertakes with nonstate funds to make our problem-solving efforts more effective.

The first issue of *Survey Reports* was published in November 1962, after Survey officials had recognized that the research and service activities of the Survey were far better known nationally and internationally than they were in Illinois. The four-page illustrated *Survey Reports,* edited by Dr. H. H. Ross until his retirement in 1969, is written in nontechnical language and brings to the reader, in Dr. Ross' words, "glimpses of the unfolding drama of scientific inquiry which goes into the Survey's investigation of Illinois' natural resources."

Four thousand copies of the first issue were distributed to Illinois farm advisers, state legislators, and registered doctors and dentists in the state in the hope that they would provide outlets to the general public, giving maximum coverage for the number of copies available at that time. Since then, the number of copies printed each month has increased steadily and now approaches ten thousand copies per month. Single copies of the *Survey Reports* are now sent to any Illinois resident who asks to be placed on the distribution list. In addition, each newly elected state senator and representative is sent a copy and asked if he wishes to receive monthly copies.

Over the years, many requests for the *Survey Reports* have been received from libraries and individuals throughout the country and from scientists in several foreign coutries. The low-key manner of reporting Survey activities is by far the best public relations vehicle available to the Survey. Its effectiveness is well-documented by letters ranging from compliments by state legislators and CBS News to letters of indignation from irate citizens who had missed issues when they moved to new residences and neglected to provide the Survey with a change of address.

With this centennial issue, 407 reports of research projects have been presented to the public in a manner designed to make the often complicated research jargon understandable to the layman. This reflects not only the vast number of research projects undertaken by Survey scientists, but, in addition, the sense of obligation that Survey personnel feel toward the residents of Illinois.

Scientists at the Survey study all aspects of our natural resources from birds, fish, and wildlife to disease and insect pests that threaten crops and ornamental plants and man himself. In the future, the Illinois Natural History Survey plans to continue its never-ending study of the flora and fauna of Illinois and to increase dramatically its investigations of pollution and pollution control, so badly needed

in this age of waste and environmental contamination.

Articles for the *Survey Reports* are prepared and edited by Survey personnel on their own time, and no state funds have been used thus far for printing or mailing the monthly issues. Sources of adequate financing are becoming exceedingly sparse, but publication of the *Reports* will be continued as long as funds can be found to support this endeavor.

Pesticide Poisoning in Illinois Children

Each year since 1961, extension entomologists H. B. Petty and Roscoe Randell have prepared a report summarizing cases of accidental pesticide poisoning among children in Illinois.

Whenever a child twelve years of age or younger ingests or is contaminated by a pesticide and is taken to a doctor, the case is reported to a local poison control center. These centers then report this information to the Illinois Department of Public Health. Dr. Norman Rose, chief of the Bureau of Hazardous Substances in the Department of Public Health, submits the yearly data to Dr. Petty and Dr. Randell after it is collected from the various poison-control centers. The data are then studied and categorized as to chemical, trade name, and means by which the material was obtained by the child.

Each year for the past nine years, 11,713 Illinois children, on the average, have been rushed to a doctor or poison-control center because the children had ingested or were contaminated with a hazardous substance. Most of these cases (61.5 percent) are accidental ingestions of medicine. Household preparations, including bleach, make up 13.7 percent of the cases. Pesticides, including fungicides, herbicides, insecticides, and rodenticides average 6.2 percent. Other substances recorded include paints (4.8 percent) and cosmetics (2.8 percent).

During the past nine years, an annual average of 728 actual pesticide accident cases was recorded among Illinois children. Of this number, an average of 161 cases yearly resulted from a child ingesting or being contaminated with a rodenticide, usually in the form of a rat or mouse bait. An average of 94 cases resulted from an insecticide used for control of ants in the home and 54 cases involved roach insecticide. In most of these cases, the insecticide was in the form of a bait. Moth balls accounted for an additional 81 cases annually.

In nearly half of the reported accidents, the pesticide was obtained by the child while it was being used, but in 16 percent of the cases it was found in storage.

The population of Illinois has increased during the past nine years and the number of cases involving accidental poisoning by hazardous substances among children has also increased. At the same time, the number of cases involving pesticides increased until 1965, but has since decreased each year to a low of 670 cases in 1969. To help reduce even further the number of pesticide poisoning cases among children, Dr. Petty and Dr. Randell make their report available and see that the information is presented at nearly all extension educational meetings throughout the state.

Suggestions for reducing or eliminating accidental pesticide poisonings among children are:

1. If baits are used, keep them out of the reach of children.
2. When woolens are stored in mothballs, be sure they are stored in a sealed container.
3. Keep all pesticides stored under lock and key.
4. Properly dispose of pesticide containers by taking them to a sanitary land fill.

Drought and Tree Diseases

Tree specialists have realized for years that many trees and other woody plants become more susceptible to attack by certain disease organisms following periods of prolonged drought. Why drought affects plants and how long or how severe the drought must be to have an effect on disease susceptibility, however, have remained unsolved mysteries.

One of the stumbling blocks that has hindered scientists in studying drought or moisture stress has been the lack of methods and equipment for measuring the internal water stress in plants. In recent years, several ingenious methods have been de-

Fungus canker on a branch of a thornless honey locust tree weakened by prolonged drought. (Photo by Dr. D. F. Schoeneweiss.)

veloped to measure these stresses, opening the way for some badly needed research on tree diseases. To take advantage of these new breakthroughs, Survey plant pathologist D. F. Schoeneweiss recently initiated a series of long-range studies on drought and its effect on disease susceptibility in trees and shrubs.

Using these new methods of measurement and placing tree seedlings in specially designed controlled environment chambers, Dr. Schoeneweiss has obtained evidence that both drought severity and the length of the drought period influence susceptibility of woody plants to attack by disease organisms. Trees in various stages of wilt were inoculated with canker-producing fungi that do not normally attack vigorous, well-watered trees. Cankers formed on trees that were severely wilted for a period of several weeks but did not form on well-watered trees or on trees that were in a stage of moderate wilt over a long period of time. In addition, cankers did not form on trees that were severely wilted for very short periods of two or three days.

Now that methods are available to accurately measure internal water stresses in intact, living plants, it should be possible to study the mechanisms of disease susceptibility and how they are affected by drought. Further research may lead to more intelligent recommendations as to how much and how often trees should be watered to keep them free from attack by many disease organisms.

New Book on Fish Management

The Van Nostrand Reinhold Company recently announced the publication of a book entitled *Management of Lakes and Ponds,* written by Dr. George W. Bennett, head of the Survey's Section of Aquatic Biology. This is an expanded edition of a book entitled *Management of Artificial Lakes and Ponds,* published in 1962, and includes most of the research information released since then.

This new edition is written in nontechnical language for lake and pond owners who are interested in managing their waters for better fishing. Anglers who want to keep up with current information on fish behavior and fishery management will also find the book very useful. Some very active areas of research not covered in the first edition are included, such as the pollution of aquatic habitats by organic materials, by-products of chemical manufacturing, oil refinery effluent, detergents, pesticides, radioactive wastes, and hot water from atomic and fossil fuel energy production.

Research on lakes and ponds has demonstrated that a body of water may support more pounds of fish one year than the next, depending upon the quality and quantity of living organisms in the water. Although aquatic biologists have

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tried for more than thirty-seven years to increase aquatic productivity through pond fertilization, no one is yet able to predict the most economical kinds and amounts of fertilizer to maximize fish production.

Included in the book is new information on hybridization among fishes in the bass, catfish, pickerel, and sunfish families, particularly on hybrids produced by crossing largemouth bass with smallmouth bass, bluegills, and green sunfish.

Considerable disagreement exists nationwide as to what kinds, numbers, and sizes of fishes should be used to stock a new or renovated body of water. Dr. Bennett summarizes in his book the various combinations that have been tested extensively and attempts to rate the chances of failure from stocking fishes out of their normal aquatic habitats. Methods of lake renovation, some old and some new, are included and there is a chapter on aquatic vegetation control by biological methods and by chemical methods.

Fish die of old age, disease, and starvation; thus, it is possible only temporarily to build up fish populations that exceed the carrying capacity of a body of water. Many more fish die of old age than are ever caught by fishermen except where fishing pressure exceeds one thousand man hours per acre per year; therefore, underfishing is far more common than overfishing.

Fish farming for channel catfish and bait minnows is expanding rapidly, particularly in the South where the growing season for fishes is eight to nine months. It is possible through supplemental feeding to increase the weight of a channel catfish from one-half to one and one-half pounds (marketable size) in one growing season. Cage culture of channel catfish is becoming popular because fish in cages are readily available for daily inspection, feeding, and finally harvesting. Fish from these farms are dressed and marketed or sold alive for private or "pay fishing" lakes.

These and many other subjects are covered in Dr. Bennett's new 375-page book. Copies of *Management of Lakes and Ponds* are available from Van Nostrand Reinhold Book Company, New York, N.Y.

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Ducks on the Wing

Rare is the person who is not stirred by the sight of chevrons or lines of ducks patterning the sky during the fall migrations of these waterfowl. Where are they headed, besides generally south? How are they guided? Do they stop to feed? If so, how often, for how long and where? Do family groups travel together? Do they fly the same route year after year? Many other questions are prompted by the sight of this annual source of wonder.

Answers to many of these questions have come from programs of trapping ducks, banding and releasing them, and recapturing them or obtaining the bands from hunters. Large-scale banding of migratory ducks in the United States first occurred in Illinois when F. C. Lincoln, a U. S. Bureau of Biological Survey biologist, banded 1,670 mallards and 57 black ducks in 1922 at the Sanganois Duck Club near Browning. The principal duck banding program of the Illinois Natural History Survey extended from 1939 through 1952. Survey wildlifers have continued banding ducks since 1952, but these later bandings were directed toward problems of homing and orientation rather than recovery data concerning migrations.

The data from duck bandings in Illinois have been analyzed and interpreted by wildlifers Frank C. Bellrose and Robert D. Crompton in a Survey Bulletin (Vol. 30, Art. 3) published in September 1970 entitled "Migrational Behavior of Mallards and Black Ducks as Determined by Banding." To round out their analysis of mallard movements in the Mississippi Flyway, they included band recoveries from mallard banding by the Bureau of Sport Fisheries and Wildlife at the Delta Marsh, Manitoba, Canada, and the Squaw Creek National Wildlife Refuge near Mound City, Missouri.

Objectives of this study were to deter-

Mallards resting on an Illinois marsh during a migration stop. (Photo from Survey Wildlife Section.)

mine the migrational patterns as shown by band recoveries of mallards and black ducks, the variation in migration patterns of ducks banded at various localities in the Mississippi Flyway, the year-to-year degree of variation in migration patterns, the period of time these ducks remained in one place in the flyway, and the timing of movements in the migrations.

An interesting facet of these studies is the discussion of the dispersion of juveniles among flocks of migrating ducks. These ducks do not appear to travel in family groups, as do Canada geese. It seems that traditional migrating routes and wintering areas become established for juvenile ducks visiting them for the first time in the company of adults who return to the areas they previously frequented.

Banding records indicate that in the Mississippi migration corridor mallards remain about 28 days at each traditional migration area they use for feeding and resting. Since an average total of 64.5 days are spent by the ducks on these areas, the birds must have two or three important feeding and resting areas between their breeding and wintering grounds. Mallards migrating from the Delta Marsh, Manitoba, area probably have only one or two major stops in their migration, since they remain on the breeding grounds later and have less than average time for lengthy stops.

Copies of this Bulletin are available to interested parties upon request from the Survey.

Ants in Review

Ants are among the best-known insects to the general public. Books have been written about ants' caste system of social organization and comparisons drawn between their societies and those of man. Ants are often a nuisance on picnics, in lawns, and in the home. Some sting severely, and many bite while spraying a caustic chemical into the site of the bite. In nature ants are important in helping to recycle natural objects such as fallen logs, stumps, sticks, fruits, dead insects and other small animals, and in aerating the soil with their galleries and nest chambers. They may damage crops by directly attacking them. (The parasol ant removes leaves from coffee trees in tropical countries.) They may harm crops indirectly by maintaining colonies of aphids on plants. (The cornfield ant maintains aphid colonies on roots and leaves of corn and other grains.) Thus ants decrease yields due to the aphid damage.

There are about seven thousand species in the world representing a bewildering variety of structures and habits. In Illinois about eighty species representing thirty-three genera are known to occur. Recognizing all of these species has always been a difficult problem. Herbert H. Ross, now retired; George L. Rotramel, now at Berkeley, California, and Survey entomologist Wallace E. LaBerge have recently published a synopsis of the common and economically important Illinois ants. This study presents profusely illustrated keys to facilitate identification of all known genera in Illinois, together with several genera expected to be found in this state. An important feature of the work is the key to the winged forms, often neglected in taxonomic works on ants.

In addition to facilitating the recognition of Illinois ants, this study contains a general discussion of their habits, life histories, and development; where they can be found; and their economic importance. It also tells how to distinguish between ants and termites and illustrates the differences between them.

This work on Illinois ants was published as one of the Survey's *Biological Notes* (No. 71, January 1971); copies can be obtained by interested persons upon request.

Teamwork on Pesticides

With increasing concern about pollution there is a demand for less contamination of the environment by chemicals. The use of biodegradable insecticides rather than the more persistent compounds used in the past is in keeping with this point of view. DDT, a persistent insecticide, is a widespread environmental contaminant found in animal tissues throughout the world. It may reach relatively high concentrations

Interior of the wet-laboratory in the new Flint Entomology Laboratory. (Photo by Survey photographer, Wilmer Zehr.)

in animals in the upper levels of food chains or webs. There are numerous examples of concentration of DDT in aquatic organisms. The chemically related but biodegradable insecticide methoxychlor is being widely considered as a replacement for DDT for these reasons.

A Survey team composed of aquatic biologist W. A. Childers and entomologists W. N. Bruce and Keturah Reinbold is investigating the effects of several biodegradable insecticides in aquatic environments. These studies are being enhanced by facilities provided in the new Flint Entomology Laboratory.

Recently this team, in cooperation with I. P. Kapoor and R. L. Metcalf of the Department of Entomology of the University of Illinois at Urbana-Champaign, completed comparative studies of the uptake and metabolism of radiolabeled methoxychlor and DDT in aquatic organisms. Two kinds of fish, Tilapia and green sunfish, exposed to low dilutions of the insecticides in water for 31 days, concentrated DDT as much as 10,600 times and methoxychlor about 200 times. When Tilapia were transferred to clean water following 12 days of exposure, the residues of methoxychlor decreased much more rapidly than did those of DDT. After 15 days 10,000 times more DDT remained in the fish than methoxychlor.

Daphnia (small freshwater crustaceans) in treated water concentrated DDT nearly the same to about twice as much as they did methoxychlor. When the Daphnia were fed to guppies to complete the food chain, DDT was rapidly concentrated in the fish reaching 8 parts per million in 20 days, whereas methoxychlor concentrations never rose above 0.17 ppm. Thus, methoxychlor is readily biodegradable in fish. However, a snail (*Physa* sp.) could not metabolize either DDT or methoxychlor and concentrated both to high levels.

The new Flint Entomology Laboratory provides facilities in which work such as this can progress more rapidly, hopefully providing us with realistic recommendations on the use of pesticides in the near future.

The Gall of Insects

A great many insects do have the gall to cause galls (tumors) to form on a wide variety of plants. Galls are fibrous growths on plant leaves or stems. They are initiated by the presence of eggs or larvae of a particular insect. This gall, grown by the plant, forms a home for the insect and provides it with both shelter and food.

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Although a specific insect determines the shape and form of the gall, it is formed entirely of plant tissue. If the same species of insect attacks several related species of plants, the galls formed appear similar to one another. When several species of insects attack the same plant, each causes the plant to form its specific type of gall. Most galls appear to be harmless to the plant, but some are damaging and can be considered economically important.

Recently, Survey entomologists Donald Webb and James Appleby have been examining species of gall-making flies of the family Cecidomyiidae (gall midges) which attack hawthorns (*Crataegus* spp.) in Illinois. Four species of gall midges have been found attacking hawthorns in this state. One species, *Trishormomya crataegifolia,* forms the thorn cockscomb gall. This gall is a short fibrous gall formed along the veins on the upper side of the leaf. The adult midge lays its eggs on the buds or branchlets in mid-April. The larvae hatch in 10–20 days and make their way to the upper side of the leaf to feed. The plant then forms a gall around each larva. The larvae emerge from the gall in late January to pupate in a cocoon placed on the fallen hawthorn leaf or in the ground. Adults emerge in early spring.

By collecting galls and rearing the larvae, all immature stages were obtained. A redescription of the adults together with a description of the immature stages has been published by Webb and Appleby in the journal *Entomological News* (1969). Another paper is being prepared on the life history and bionomics of the thorn cockscomb gall midge. A related species of midge causing galls to form on hawthorn is now being reared and preparations are being made to study the other species of hawthorn gall midges occurring in Illinois.

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APRIL 1971, NO. 102

Keep Those Tootsies Warm!

As the blooming of tulips marks the approach of spring in central Illinois, so does the arrival of mourning doves. Well, that's not quite the whole truth. Although the mourning dove is principally a migrant species that breeds in the northern states and winters in the south, some doves may winter in local areas within their northern breeding range, including northern and central Illinois. Doves that winter in these northern climes are often subjected, for a duration of several days, to stresses of low temperatures and of accompanying food shortages due to accumulations of snow and ice. Doves so exposed must either make some physiological adjustments to conserve energy, or perish.

Most research on energy expenditures of birds in winter indicates that they maintain a constant body temperature by increasing their metabolic rate as the environmental temperature decreases. Hence, survival is essentially dependent upon the bird's ability to replenish his energy stores by the intake of food. How then does the seed-eating mourning dove survive a winter storm in the north if his food is scarce or unavailable?

To investigate just how some doves do manage to survive the winter in central Illinois, Survey wildlife specialists R. F. Labisky and D. L. Ivacic subjected doves trapped in the wild, that were winter-acclimated to central Illinois, to simulated two-day storms during January and February, 1970. The experimental "storm" conditions consisted of two consecutive twenty-four-hour cycles of decreasing environmental temperatures at night and of increasing temperatures during the day. The doves received no food during the trial.

The metabolic expenditures of females exceeded those of males and those of juvenile birds exceeded those of adults. Following this lead, Labisky and Ivacic subjected doves to the "storm" cycle until they succumbed, and found that males could survive markedly longer than females. In fact, one male dove survived the experimental conditions for four and a half days before dying. These findings offer a tentative explanation for the usual overwhelming preponderance of males in flocks of doves wintering within their northern breeding range.

Although the metabolic rates of doves

Normal toes compared with frostbitten toes of mourning doves that wintered in Illinois. (Photo by former Survey Photographer William Clark.)

increased with decreasing environmental temperatures, the Survey researchers found that the rates then decreased when the doves were maintained at 0°F., the lowest temperature, throughout the night. These reductions in energy expenditures at low temperatures were paralleled by modest reductions in body temperature. Hence, mourning doves, particularly adult males, apparently possess the ability to reduce their energy losses at low environmental temperatures, without food, by lowering their body temperature. This mechanism enhances the dove's ability to survive winter on its northern breeding range.

Even though some doves do survive the rigors of the northern winter, many of the survivors will display a loss of toes, usually from frostbite, to show for their foolhardiness.

Parasites Help Control Alfalfa Weevil

The use of insecticides to control crop-feeding insects increased in the past few decades to the point where it was the major, if not the only, recommended control for most field crops. Now, however, scientists are searching for ways to keep crop losses due to insects at a minimum with much smaller doses of insecticides, so that environmental contamination can be curtailed. To accomplish this, intensive investigations are under way in an attempt to utilize biological controls such as predators and parasites of plant-feeding insects. Combining biological control with minimum insecticides application is known as integrated pest control. Entomologists at the Survey have been very active in this field.

Alfalfa is a field crop that supports a wide range of insects. These include not only destructive insects but pollinating insects and insects that are predators and parasites of plant-feeding insects as well.

The alfalfa weevil, *Hypera postica,* continues to be the most important single pest of alfalfa in Illinois. Severe infestations of the weevil have necessitated the intensive use of chemicals in order to produce high quality alfalfa. Survey scientists now feel, however, that the use of pesticides on alfalfa should be restricted and greater use should be made of parasites and predators of the weevil that inhabit alfalfa fields. To study this problem and develop an effective, integrated control program, Survey entomologist Ed Armbrust is conducting a series of studies on these predators and parasites and how their populations are affected by insecticides.

Because alfalfa is a crop which can tolerate a small population of plant-feeding insects without a significant reduction in yield, alfalfa is well suited to an integrated pest control program. To aid in controlling the alfalfa weevil, a parasite from Europe, *Bathyplectes curculionis,* has been introduced into alfalfa fields in the United States. Dr. Armbrust reports that the tremendous success with this parasite has made it a very significant factor in control of the alfalfa weevil. An integrated control program is now possible which will utilize both insecticides and natural biotic agents. With the assistance of the parasites, there is little need for persistent insecticides. In fact, persistent compounds work to a disadvantage in that they lower the weevil populations too much, resulting in an excessive reduction in numbers of parasites.

Alfalfa weevil populations can now be managed with lower amounts of insecticides and these toxicants can be applied in the fall when crops are dormant and there is little change of crop contamination.

Aggressive Behavior of Green Sunfish

A number of sunfish species are present in Illinois lakes and streams. Many of these species nest together in shallow water during the spawning season. Since hybridization studies have shown that there is little incompatibility between egg and sperm of different species, how does a species such as the green sunfish, *Lepomis cyanellus,* continue to reproduce its own kind without freely hybridizing with other species?

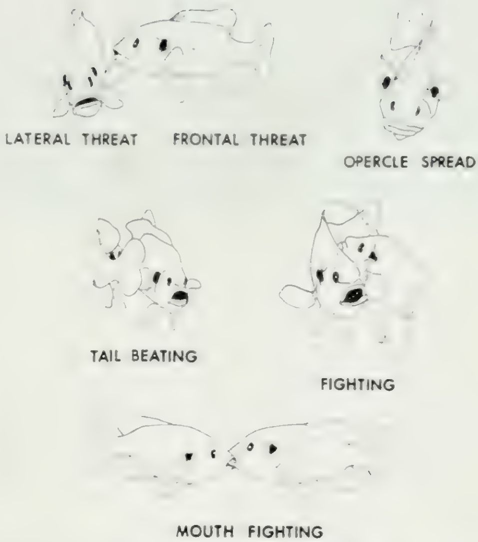
Male green sunfish are colonial nesters, constructing their nests adjacent to one another on spawning beds in shallow water. Each male guards his nest vigorously against all other fishes. However, females are attracted by the nesting activities and aggressive displays of the males, thus reproductive behavior and aggressive behavior are closely related. Ritualized displays

and color patterns have evolved to inhibit physical combat so that the fish do not harm each other and so that reproductive activities are not interrupted.

To learn more about the behavior of green sunfishes during spawning, Survey research assistant John A. Tranquilli recently studied agonistic behavior in paired fishes in an experimental aquarium. Fifteen aggressive acts and three distinct color patterns were observed and recorded during these studies. An analysis of the agonistic acts of paired males indicated two general patterns or pathways of behavior. One pathway proceeds from lateral threat through frontal threat, opercle spread, bite, and fighting, illustrating the typical behavior of an aggressive fish. The other pathway, showing typical behavior of a threatened fish, proceeds from lateral threat through tail beating to fighting and actual biting. The fish continued to fight until one male was able to establish dominance. No physical damage was observed as a result of these aggressive encounters.

Three distinct color patterns were observed. Light coloration is exhibited by frightened males and is characterized by a light body color where the pigment appears washed out and the iris of the eye is a light yellow. Male green sunfish are as aggressive toward females approaching their nests as they are of other males. Intermediate coloration is typically shown by females when they are trying to enter a male's nest and appears to be mechanism to inhibit male aggression. Males also exhibit intermediate coloration when they become frightened by losing a round in the battle for dominance during paired encounters. Dark coloration occurs when pigmentation becomes very pronounced in both the iris of the eye and the body so that the fish turns almost totally black. Dark coloration is displayed by subordinant males and a "black eye" is an unfailing sign of defeat.

Results from this study indicate that in nature the major barrier to hybridization between sunfish species is the differential behavior and cryptic color patterns exhibited by the fishes during spawning.



Aggressive displays of male green sunfish. (Drawings by J. A. Tranquilli.)

Never-ending Search for Disease Control

When a disease is found destroying or damaging plants in a field or garden, it is usually too late to apply control measures that will save the plants. Plant pathologists are asked to recommend control measures that will prevent recurrence of a disease or at least hold it to a minimum of damage. Often no effective control measures are known. It then becomes the pathologist's job to develop such measures.

The methods used by plant pathologists to develop effective disease control measures are quite varied. A common approach is to try control measures that have been successful against another disease. Certain modifications are usually necessary to fit the problem at hand. For example, when the commercial gladiolus growers in Illinois came to the Survey in 1939 and requested help in controlling their diseases, the late Dr. D. B. Creager was assigned to the project. Before Dr. Creager came to Illinois he had used certain chemicals to treat seed to control smut diseases. He reasoned that some of the same chemicals used to control wheat smut might also control Fusarium rot of gladiolus. He experimented with many chemicals and found that one of the organic mercury dust compounds used to

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control wheat smut also gave excellent control of Fusarium rot of gladiolus, provided the mercury compound was incorporated in a dip and used to treat the gladiolus corms before they were planted.

It seemed then, that the problem of Fusarium rot of glads was completely solved. This, however, did not prove to be the case. The organic mercury which Dr. Creager had found so effective was withdrawn from the market. In the meantime, Dr. J. L. Forsberg, who had succeeded Dr. Creager at the Survey, found that a new organic mercury compound in a liquid formulation was more satisfactory than the compound Dr. Creager had used. Commercial glad growers successfully used this compound for several years.

Now that all mercury compounds used as fungicides have become almost completely unavailable, commercial growers have found that they must use some other material to control Fusarium rot. Again the Survey has an answer. During the past two years Dr. Forsberg has been testing a new, nonmercurial fungicide, known as benomyl. In these tests benomyl has been especially effective in controlling Fusarium rot. The product has become available to growers this year.

The search for new materials for disease control, however, still goes on. Not so much because new materials might give better results than those that have been used, but because materials currently being used may become unavailable.

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MAY 1971, NO. 103

Dr. Harlow B. Mills

It is with deeply felt regret that we must announce the death of our beloved former chief, Dr. Harlow B. Mills, on Monday, April 5, 1971, at the Brackenridge Hospital in Austin, Texas.

Dr. Mills served as chief of the Survey for nineteen years until his retirement in 1966. This period was one of growth in size, in leadership in research, and in service to the state of Illinois for the Survey. Much of this development was due to Dr. Mills' leadership and interest in research and development and to his remarkable ability to get people to cooperate.

During a leave of absence from the Survey in 1962–63, Dr. Mills was chief scientist for the National Science Foundation in its Latin American office at Rio de Janeiro and was consultant to the U.S. Departments of Agriculture and Interior on pesticide problems. He was a national authority on the Collembola, a large group of tiny, soil-inhabiting insects and published many papers on these.

Dr. Mills was married to the former Esther Brewer who preceded him in death. He is survived by a daughter, Mrs. Timothy Lewis of Champaign, Illinois, and two sons, Dr. David Mills of College Park, Maryland, and Gary Mills of Edina, Minnesota.

Little Blue Herons and Insecticides

Persistent insecticides are known to accumulate in tissues of many species of our wildlife. But to what extent these chemicals concentrate and what damage they do are topics which need documentation. One problem is obtaining a large enough sample of a species of bird or other animal to study in this respect.

Breeding colonies of little blue herons have recently become established in shortleaf pine plantations in southeast Missouri. Chlorinated hydrocarbon insecticides (such as DDT, Aldrin, Dieldrin and heptachlor) have been used in this area since about 1949. Wildlifer Robert E. Greenberg of the Survey has been studying residues of certain of the chlorinated hydrocarbons in eggs, nestlings, and adults of these herons. Paul Heye, Associate Professor of Biology at Southeastern Missouri State University, Cape Girardeau, collected the specimens, and they were sent to the Survey's wildlife-

Dr. Harlow B. Mills, 1906–71. (Photo by Survey photographer Wilmer Zehr.)

pesticides laboratory where they were analyzed for residues of DDT, aldrin/dieldrin, and heptachlor using a gas chromatograph with an electron capture detector.

Results of the analyses indicated that the herons were contaminated with higher levels of DDT residues than with those of aldrin/dieldrin or of heptachlor. DDT residues were detected in all specimens that were analyzed individually. Maximum levels of DDT residues in eggs were 1.34 part per million in 1967 and 2.67 ppm in 1968. Breast muscles and brain tissues of adult herons collected in 1967 contained 5.56 ppm and 2.09 ppm respectively of DDT residues. Adults appeared to have significantly higher levels of DDT residues than did the nestlings.

Dieldrin residues were detected in nine of eighteen eggs from 1967 and two of ten eggs from 1968. In adult herons from 1967 dieldrin residues were found in six of eleven breast muscle samples and nine of fourteen brain samples. Maximum levels of dieldrin residues were 0.47 ppm in eggs, 0.21 ppm in breast muscle and 1.06 ppm in the brain.

Heptachlor residues were found in only five of eighteen eggs from 1967 and in none of the ten eggs from 1968. These residues were found in adult herons in two of eleven breast samples and two of fourteen brain samples from herons collected in 1967. Maximum levels of heptachlor residues were 0.15 ppm in eggs, 0.25 ppm in breast muscles, and 0.14 ppm in brain tissues.

Adult little blue herons feed in meadows, marshes, streams, and ponds within a few miles of the heronries. They feed on such items as small fishes, frogs, lizards, snakes, turtles, crustaceans, spiders, and insects. Analysis of a pooled food sample (mostly small crayfish plus a few minnows, earthworms, and some aquatic vegetation), taken from the crops of nestlings in 1968, indicated 0.01 ppm DDT but no other residues. It seems likely that the DDT residues detected in the nestlings and in the eggs were due to ingestion of contaminated food and to subsequent concentration at relatively high levels in the lipid-rich egg yolks.

There are no indications of a major change in the number of little blue herons nesting in the area studied. Nest counts in early June, 1965 through 1969, include a range of 3,887 to 4,759 nests with an average of 4,218 for the five years.

Least bittern eggs from southern Louisiana have been reported to contain DDT residues ranging in amounts of 0.15 to 0.42 ppm. These levels are similar to those found in this study of little blue herons, which could be expected as the food habits of these two birds are similar.

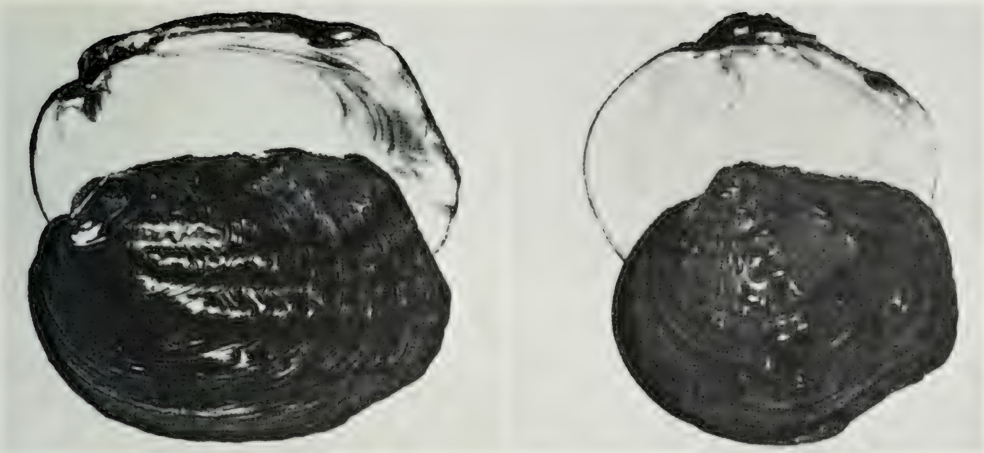
Mussels, Buttons, and Pearls

Early in this century the Illinois River was probably the most productive mussel stream per mile in this country. At that time mussel shells were in great demand for use in manufacturing buttons. Prior to 1907 most mussel fishing on the Illinois River was done by pearl hunters. One pearl found in a mussel taken at Chilicothe in 1911 was valued at three thousand dollars. After 1906 mussels were taken primarily for the sale of shells to button-shell buyers, and and the pearls were of secondary interest.

The maximum commercial shell yield of the Illinois River occurred in 1909 and amounted to thousands of tons of good button shells. By 1911 mussels of certain parts of the Illinois River were beginning to be affected by pollution, siltation, and mussel fishing. After World War II the great increase in the use of plastics in buttons had a further serious effect on the few mussel fishermen remaining along the Illinois River.

About 1962 a renewed interest in mussel fishing on Illinois streams was stimulated by the market demand for Illinois shells by the Japanese pearl-culture industry. American shells provide the thickness required for producing the nuclei inserted into the oysters around which a pearl is formed. The Japanese mussels have shells that are too thin to be used for this purpose, whereas many American mussel shells are ideal. This industry has grown to such an extent that, in 1966, 1,279 mussel fishing licenses were issued and a total of over 3,500 tons of mussels were harvested in Illinois. This represents a value of over $600,000.

Soon after the increase in mussel fishing



The three-ridge mussel (on the left) and the maple leaf mussel (on the right), two common species in the Illinois River. (Photo by Dr. G. W. Bennett.)

in the early 1960s, Survey aquatic biologist William C. Starrett and members of the Illinois Department of Conservation realized that no current information was available concerning the state's mussel fauna, the status of laws governing mussel fishing (designed for mussels suitable for button manufacture, not pearl culture), and the extent of the new fishery. Dr. Starrett began a study of the Illinois River mussel fauna in order to determine what species were present and what changes in the fauna and distributional patterns occurred during the past century and to better formulate a sound basis for managing the mussel resource of this river.

In the 1966 to 1969 period 4,247 live mussels were collected and examined. Twenty-four kinds of mussels were found to be living in the Illinois River, although five of these were represented by single specimens. The three-ridge mussel was most abundant and represented 62.4 percent of the mussels collected. Other fairly common mussels were the pimple-back, the maple-leaf, the washboard, and the floater. This compares with at least forty-nine different kinds of mussels present in the Illinois River in the 1870-1900 period. Since that time twenty-five kinds of mussels have been extirpated from these waters and many of the surviving species are limited in numbers and distribution. Domestic and industrial pollution have been major factors in this reduction in numbers. Siltation has probably also been effective in reducing numbers and eliminating certain species.

This study has been reported in detail in an *Illinois Natural History Survey Bulletin* titled, "A Survey of the Mussels (Unionacea) of the Illinois River: a Polluted Stream," by William C. Starrett. This publication includes colored pictures of some of the extant species of mussels as well as a wealth of information from present-day and past collections. The Bulletin is available to interested persons upon request.

Hopper Predictions

Grasshopper populations almost exploded in 1970, reaching the highest level in several years. Damage to marginal rows of soybeans was common in central and southern Illinois, and occasionally entire fields required treatment. Good growing conditions and lush grass in fence rows and along roadsides provided ample food for grasshoppers and slowed migrations into corn and soybeans, thereby averting serious crop damage. This year may be a different story. Flower and vegetable gardens as well as farm crops in areas where numbers were high last year may be damaged this year, and the reason is that grasshopper adults deposited eggs in pods in the soil last fall. Two species of grasshoppers were abundant –the big green to yellow differential grass-

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hopper and the smaller grey one, the red-legged grasshopper. The differential females deposited eggs in the soil of grass sods, grass waterways, roadsides, fence rows, and even lawns. The red-legged females deposited their eggs in clover and alfalfa fields. These eggs will hatch in June.

With ideal conditions for grasshopper survival, almost any area in the state could have problems, but central and southern sections are the areas where severe infestations are expected. Dry weather, particularly during the egg hatching time in June, will be advantageous to grasshopper survival. Hard, beating rains as the hoppers are hatching will kill many of them, but rains which occur several days after peak of hatch are not as helpful in controlling grasshoppers.

Time to apply insecticides like carbaryl, diazinon, malathion, or naled is during the hatching period while the grasshoppers are still concentrated in the egg bed site. Watch egg bed sites during June, in this way using less insecticide by applying it in a concentrated area. Another advantage is that hoppers are easier to kill when they are small. Sometimes a second application is needed if hatching is prolonged.

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Petal Protrusions — New Virus in Glads?

In recent years Survey plant pathologists J. L. Forsberg and W. Hartstirn have attempted to separate the many viruses that make up a disease complex in gladiolus. During the course of this work, several abnormalities have been observed for which the causes are as yet unknown. One of the unusual conditions observed in several glad varieties is called "protrusions." This condition is apparent only in the flowers and shows up as cone-shaped, hollow protrusions that are distortions of the petals. On a single plant these protrusions may occur on any number of florets, and a given floret may have from one to all of the petals affected.

Drs. Forsberg and Hartstirn have shown that this condition can be carried over from generation to generation through glad corms or bulbs. It has also been passed on through most, but not all, of the bulblets or cormels. In this respect the condition is very similar to the white break disease of gladiolus which is caused by the cucumber mosaic virus.

Efforts to determine the cause of protrusions have thus far eliminated insects or insect toxins, fungal or bacterial diseases, and nematodes. The two remaining possibilities, viruses and genetic factors, are the most difficult to distinguish between. Information gathered thus far leads the Survey pathologists to believe the problem may be due to a virus or viruses. If protrusions are virus-caused, the problem is showing up about the same way that white break, the most important disease of glads, showed up some thirty years ago. Because of the potential importance of the problem, further research on the nature of protrusions is now under way.

When protrusions occur, symptoms may range from barely noticeable to severe. This too is the normal pattern observed for white break. In most cases protrusions do not alter the size of the flower spike. One exception is where the flower spike is extremely distorted and short, a condition which the Survey scientists refer to as "club head." In club-headed spikes, the individual florets may not open or may be so distorted as to have abnormal numbers of petals and anthers. Research on club-heading is in-

Petal protrusions on florets of a gladiolus flower spike. (Photo by Survey photographer Wilmer Zehr.)

cluded with studies on protrusions since all of the club-headed spikes exhibit protrusions on the petals.

The observance of new or previously unreported diseases in plants occurs constantly. By studying these diseases as soon as they are first observed, scientists hope to develop methods of prevention or treatment before the disease becomes a serious problem. If protrusions in glads is a virus disease, methods to prevent spread are badly needed. If the problem is genetic, plant breeders that hybridize gladiolus will need to know which glad varieties carry the genes for this condition and avoid these in their breeding programs. Hopefully, further research at the Survey will shed some light on these questions.

Worm Parasites of Harvestman

Nematodes are small slender roundworms, usually microscopic in size, which occur in tremendous numbers throughout the world. Nearly all nematode species go through several larval stages from egg to adult. Some species are free-living in water or soil throughout their life cycle; others have stages that are parasitic on plants or animals.

Nematodes of the family Mermithidae are small, smooth, filiform worms which are parasitic in the juvenile stage in terrestrial or fresh-water invertebrate hosts. Like many other nematodes, they develop to advanced stages within the host then leave and develop to sexual maturity, where they mate and lay eggs as free-living soil inhabitants. Eventually an infective stage, either eggs or juvenile larvae, must be taken in by the host to complete the life cycle. Merithmids differ from many other nematodes in that they do not feed as adults.

These parasitic worms are commonly found in insects; and since the emergence of the juvenile larvae kills the host, they are of considerable economic importance as insect parasites. Among groups closely related to insects, merithmid nematodes have only been found in spiders and harvestman (commonly known as daddy-long-legs) and records of these parasites are particularly rare in harvestman.

While engaged in ecological studies of spiders and ants in the University of Illinois' Brownfield Woods near Urbana, Survey taxonomist J. D. Unzicker and former Survey staff member George Rotramel discovered a parasitized harvestman containing two merithimid nematodes. These worms, belonging to the genus *Hexamermis,* had not previously been known to parasitize harvestman. This discovery has been reported and should prove useful in gaining a better understanding of the role these unusual parasites play in nature in affecting populations of invertebrates such as harvestman.

The Mystery of Sand Prairie Formation

Some places in Illinois look like useless waste land to many people but to the biologist they may be areas of great value for the study of biological laws and principles. One such place in the state is the Thomson-Fulton Scientific Study Area, a stretch of sand terrace that lies between Thomson in Carroll County and Fulton in Whiteside County.

An assemblage of grasses, legumes, daisies, and other herbs grow in the sand. This vegetational cover is called sand prairie. Unless disturbed by outside forces, it continues basically unchanged year after year. Sand itself, however, is not a stable surface since wind easily moves it about. Winds moving the sand from one place and depositing it in another produce blowouts and dunic surfaces on the otherwise level terraces. This type of disturbance is a natural one. Eventually plants grow on the exposed surfaces to form a stable community. The progression of plant species from the first pioneers to those of a stable community is termed "succession."

One question scientists have asked is "How long does it take for a prairie cover to develop on an area of bare sand?" The answer is being sought in the Thomson-Fulton Scientific Study Area.

In 1967, the Illinois Department of Conservation purchased a sizable acreage to be set aside, along with holdings of the U. S. Army Corps of Engineers and those of the Bureau of Sports Fisheries and Wildlife, as an area for scientific study. About the time

Aerial photo of a flock of blue and snow geese taken at Cape Henrietta Maria, Ontario, Canada. (Photo by H. C. Hanson.)

of the purchase, a leasee plowed twenty-three acres of this land and planted watermelons. In the fall of 1967, the melon vines were removed and a bare sand surface remained.

In 1968, Survey botanist R. A. Evers began a study of plant succession in the area. He staked out three plots: one in the unplowed prairie, one in a combination of unplowed and plowed land, and the third in plowed sand. He now examines these plots two to four times each year during the growing season to observe and record changes that occur. In the fall of 1968, Dr. Evers found seven species growing in the plowed sand plot. By the fall of 1970 he observed twenty-eight different species in the plot, eight of which were grasses usually found in sand prairie. Slowly the prairie is coming back, occupying the bare sand.

It will take more time before the plowed area will have a plant composition similar to the unplowed land, but how long this will take is not known. When this question is eventually answered, it will help solve problems where restoration of native landscape in Illinois is desired.

Goose Population Forecasting

Since the end of World War II, the federal wildlife agencies of the United States and Canada have made a concerted effort to assess duck populations in midsummer in order to have information on which to base hunting regulations for the following autumn. These forecasts are based on counts of ducks made from planes flying at low elevation along sample transect lines. Much of the duck range in the contiguous United States, Canada, and Alaska is sampled by this method.

Although geese are also observed during these surveys, forecasting goose populations has received less attention for several reasons. The secretive habits of geese, plus the fact that they spend much time foraging for food on land, makes geese less readily observed than ducks from the air.

In order to better forecast goose populations, Survey wildlife specialist H. C. Hanson and H. G. Lumsden of the Ontario Department of Lands and Forests have experimented with aerial photography. Extensive tests conducted since 1958 show that interpretable photographs can be taken from small planes flying at 200 feet using a 250 mm telephoto lens or at 400 feet using a 500 mm lens.

Information obtained in this manner on populations of three blue and snow goose colonies nesting along the south and west

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coast of Hudson Bay has been particularly rewarding. These colonies, which are located at Cape Henrietta Maria, Ontario, Cape Churchill, Manitoba, and near the McConnell River, North West Territories, all migrate down the Mississippi flyway and winter along the Louisiana and east Texas coastal areas.

Blue and lesser snow geese are now regarded by ornithologists as being color phases of the same Canada goose subspecies. These contrasting plumages have long intrigued scientists interested in population genetics and breeding compatibility. The information gained by Hanson and Lumsden through aerial photography shows that the McConnell River colony, which became established in the early 1940's and now may contain as many as 100,000 birds, is comprised of about 24 percent blue geese and that annual variations in the numbers of blue-phase birds in this colony fluctuate about this mean. In contrast, the Cape Henrietta Maria colony, which also became established in the 1940's, and is estimated to contain 40,000 birds, is now comprised of about 72 percent blue geese. This component of the colony has shown an annual rate of increase of 0.62 percent.

After the young have hatched, blue and snow goose families join together and for a few weeks form flocks that may total over 1,000 birds. Counts of the goslings and adults in photographs of such flocks have provided valuable information on the relative success of the nesting season. When such data were analyzed in relation to information obtained on the gulf coast as to the percent of adult pairs accompanied by young, average brood size, and overall age ratios, significant correlations were found. Consequently, a technique of proven value is now at hand that can be used to assess blue and snow goose populations prior to the hunting season and hence provide administrators with a basis for setting hunting regulations.

These findings, made in collaboration with the Manitoba Department of Mines and Natural Resources and the U. S. Bureau of Sport Fisheries and Wildlife, will be reported in an extensive forthcoming bulletin to be published by the Ontario Department of Lands and Forests.

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Fishes, Streams, and Ecology

Like human beings, fishes are adaptable creatures that, as a group, can tolerate much habitat abuse, but there are many kinds of fishes and their ecological tolerances vary tremendously. Their mere presence indicates little about the condition of a stream, but a knowledge of the assemblage of species and their numerical relationships provides the ichthyologist with an excellent biological picture of the water course and its well being. When such information is available over a long period of time, fishes are obviously one of the most sensitive indicators of the quality of the aquatic environment.

From time to time for over a hundred years, Survey ichthyologists have conducted censuses of Illinois fishes so that, in a sense, changes in the aquatic environment have been monitored all this time. A particularly thorough collecting program, directed by S. A. Forbes, spanned the period from 1876 to 1905 and culminated in publication of the classic *Fishes of Illinois.* Another program begun by P. W. Smith in 1950 and recently completed, is more thorough, thanks to modern transportation facilities. An enormous amount of information on changes in fish populations and aquatic habitats in Illinois has been assembled by comparing distributional patterns and census data from the two surveys. This information is available to interested agencies.

Analysis of these data is well enough along that most of the streams in the state can be assigned a rating of excellent, good, fair, or poor on the basis of species composition of the many collections available. A record of the species formerly present enables the ichthyologist to know the potential of each stream, to detect long-term changes, and to identify the factor responsible for each species' change in status.

For example, based on the amount of species diversity and presence of unusual fishes, some of the outstanding streams in the state are (A) Apple River, (B) Kishwaukee River, (C) Kankakee River, (D) Big Bureau Creek, (E) Mackinaw River, (F) Kickapoo Creek, (G) Middle Fork

Some of the Illinois streams that still have rich fish faunas and unusual species. See text for names of streams.

(of the Vermilion of the Wabash), (H) Embarras River, (I) Little Wabash River, (J) Big Creek, (K) Lusk Creek, and (L) Clear Creek. The least modified and therefore the most valuable stretches of these streams are shown on the accompanying map.

Based on the same criteria, some of the most deteriorated streams are certain tributaries of the Des Plaines River in Cook and Du Page counties, the Saline River system of southeastern Illinois, the upper Illinois River, small tributaries of the Mississippi River in the greater East St. Louis area, the Big Muddy River upstream from Murphysboro, Crooked Creek in Marion and Clinton counties, and the West Branch (of the Salt Fork) in Champaign County.

Eight of the 193 species of fishes that have been recorded from Illinois waters are now extirpated and 60 others show clear-cut evidence of range shrinkage and decimation. An objective assessment of factors responsible for the extirpation and decimation of these fishes reveals that they rank as follows: (1) excessive siltation, (2) drainage of natural lakes and sloughs, (3) desiccation of small streams during the drought periods of recent decades, (4) interactions between ecologically intolerant and aggressive foreign species following modification of the watershed, (5) pollution other than silt, and (6) dams and impoundments. The dramatic effects of siltation, drainage, and desiccation have already taken their toll. The effects of species interactions, pollution, and mainstream impoundments will become more critical in the future and will require constant surveillance by a conservation-minded public.

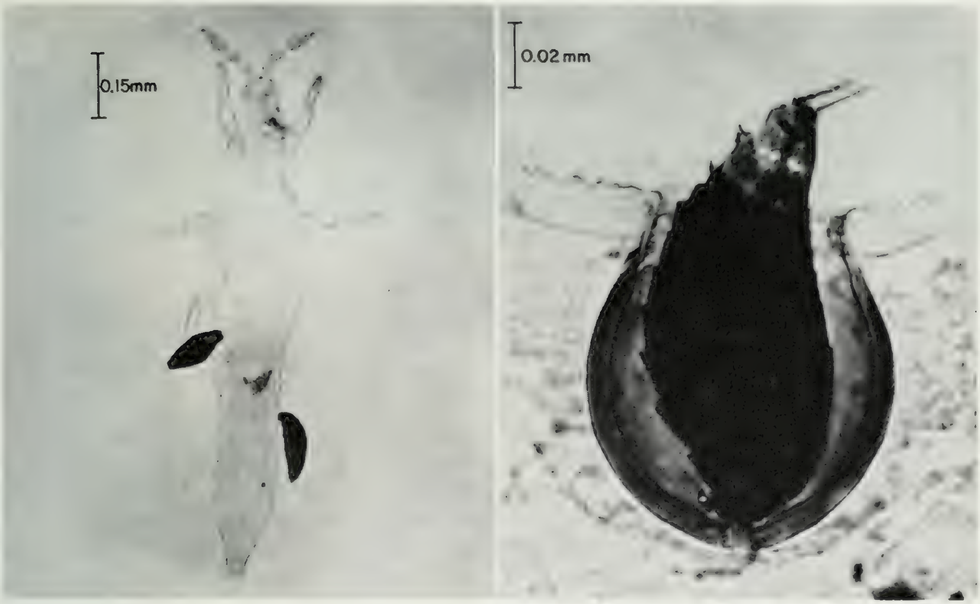
The Pheasant: A Tough Act To Follow

That raucous rascal, the cock pheasant, plays second fiddle to none in popularity as a small game species among Illinois hunters. Small game hunting statistics collected for the 14 years from 1956 to 1969, by wildlife specialists William L. Preno of the Illinois Department of Conservation and Ronald F. Labisky of the Survey, revealed that nearly half of all resident, small-game licensees hunted pheasants annually. And despite the decline of about 20 percent in resident license sales between 1956 and 1969, the restricted distribution of the bird within the state (the pheasant inhabits the northeastern third of Illinois only), and the wide fluctuation in pheasant abundance, this game bird attracted more than 200,000 individual hunters into the field during 13 of the designated 14 seasons. Also, the number of pheasant hunting trips per pheasant hunter per season, which averaged 4.3 for the 14 years, increased — due principally to corresponding increases in the length of the hunting season — from 3.5 in 1956 to 5.6 in 1969, which offset considerably that loss in hunting effort attributable to the decline in license sales. Hence, the number of hunter-trips for pheasants in Illinois, which averaged 965,000 annually for the 14 years 1956–69, was reasonably stable — ranging from a low of 805,000 in 1965 to a high of 1,160,000 in 1969.

The harvest of cock pheasants by Illinois hunters averaged 793,000 annually for the 14 years, 1956–69, with each pheasant hunter contributing 3.5 cocks to the annual bag. The annual harvest of cocks peaked at 1,064,000 in 1963, but had declined to about half that level — 539,000 cocks — just two autumns later, in 1965. Correspondingly, the seasonal bag per pheasant hunter was 4.4 cocks in 1963 but only 2.6 cocks in 1965.

Only two Illinois counties — Ford and Livingston — yielded an annual harvest that averaged more than 100 cock pheasants per 1,000 acres of land area for the 14 years, 1956–69; similarly, only three counties — Du Page, Lake, and Ford — hosted pheasant hunting pressure that exceeded 100 hunter-trips per 1,000 acres annually. The five top-ranked counties of Illinois in numerical kill were: Livingston, Champaign, Iroquois, Ford, and McLean. These counties yielded 32 percent of the total harvest of cock pheasants in Illinois for the 14 years, 1956–69. Interestingly, 70 percent of the pheasant hunting effort expended and 63 percent of the cock pheasants harvested annually in Illinois were traceable to hunters that hunted within their county of residence.

In final analysis, Illinois hunters were



Second stage larvae of the western flower thrips. Left, Planidia of an ectoparasitoid wasp attached by their mandibles to the integument. Right, Planidium partially imbedded in abdomen. (Photo by Thomas H. Wilson.)

willing to spend twice as much effort to bag a pheasant than to bag any other Illinois small game animal, including the mourning dove, bobwhite, fox squirrel, gray squirrel, and cottontail. That's quite a tribute to the colorful bird from Asia who makes his way in the corn and soybean desert of our Midwest!

Little Wanderers on Thrips

The western flower thrips *Frankliniella occidentalis* is an inconspicuous insect measuring only 1.5 mm in length, and it may be found within the petals of most flowers in southwestern United States. While recently studying thrips collected by Survey entomologist Tim A. Cooley from broomweed flowers in El Paso, Texas, graduate research assistant Thomas H. Wilson observed that these little creatures have big problems. Attached to the abdomen of many larval thrips were planidia, meaning "little wanderers" in Greek, of ectoparasitoid Chalcid wasps. These planidia are the first ectoparasitic insects ever recorded on thrips in North America.

Ordinarily this type of planidium is an ectoparasitoid of larval ants. The adult wasp deposits its eggs in the flower bud or petal. This is indeed a strange habit for an insect parasite since the eggs are usually deposited on the host. The planidium hatches and moves by looping motions to the desired part of the flower, where it assumes an erect waiting position by propping itself up on its anal spines. The planidium remains motionless until a host, preferably an ant but in this instance a thrips, comes within its reach. At this time the planidium suddenly becomes active, swaying back and forth in an attempt to attach itself by its mandibles to the prospective host. The adult ant then transports the planidium to its nest where the planidium drops off and attaches to a full-grown larva. The planidium feeds on the ant larva and remains attached while the ant larva spins the cocoon in which it pupates. The wasp larva continues to grow and soon develops into a stout, inactive semipupa. The ant workers assist the larval wasps by removing the cast skins during each molt and by pulling the adult wasp out of the pupal cocoon just as happens with the emerging adult ants. The ant foragers even feed and groom the adult wasp before the wasp leaves the ant nest just as if it were a worker ant. The adult wasps then mate and deposit their

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eggs in flowers thus completing the life cycle.

The planidia were found attached by their mandibles to the integument of the minute first stage larvae of the western flower thrips and were partially embedded in the larger second stage larvae. The thrips larva produces a thick bell-shaped capsule surrounding the planidium. A food channel was observed at the base of the capsule through which the planidium feeds. It is not known at this time whether the western flower thrips is a true or an accidental host of this ectoparasitoid wasp.

Soybean Insects

The need for an international reference center for soybean research was recognized by Survey entomologist W. H. Luckmann in 1968. An applied research center to meet this need recently has become operational. One major facet of this center is the Soybean Insect Synoptic Collection that is housed in the Flint Entomological Laboratory.

Since 1969 the collection has grown to some twenty thousand specimens representing approximately eight hundred species of insects. The collection is truly international for it includes material from India, Indonesia, Malaya, the Philippines, Argentina, Brazil, Colombia, Equador, and the United States. The insects were collected by cooperating scientists, and members of the Survey and the University of Illinois at Urbana-Champaign. It has also taken international cooperation to identify these specimens.

One basic function of the collection is to aid in the identification of soybean pests whether they occur in the United States or elsewhere. It is anticipated that this service will provide an early warning system for detecting and monitoring the spread of new insect pests. Examples of two pests that are being closely watched are the girdle beetles *Oberea brevis* and *Dectes texanus*. The former occurs in India, and the latter is fast becoming a major pest in the southeastern United States.

Bio-systematic and ecological data obtained with every sample are processed through a computer program that was especially written for this project. The program can retrieve lists of species by family and order with their respective frequency of occurrence in the collection. Lists can be prepared following up to two hundred combinations of parameters such as country, state, county of origin, meteorological conditions of the sampling date, host plant species and variety, stage of development, neighboring crops. With the expansion of the collection increasingly meaningful correlations will be drawn that will be of great help in the process of decision-making and development of pest management programs on soybeans based on sound ecological knowledge.

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Lost and Found — One Beetle

Occasionally a plant or animal species is described and classified following collection of a single individual. Many years may pass before another individual is collected that fits the original description. During the interim periods, such a species is often referred to as a "lost" species.

There could be many reasons for the apparent disappearance of a species, including such things as changes in climatic factors. Quite often, however, the lack of additional specimens is due to the simple fact that collections are not being made in the right habitat for the species at the right time.

A "lost" species of bark beetle, *Phloeotribus scabricollis,* whose original description was based on one individual collected fifty-five years ago in Indiana, was recently rediscovered in Illinois by Survey entomologist J. E. Appleby. This supposedly rare beetle was found in considerable numbers feeding on the shrub, wafer ash, at the Morton Aboretum, Lisle, Illinois. Adult beetles were observed drilling holes at the base of leaves, frequently causing the leaves to dry up and die.

Following identification of the species by Survey taxonomist M. W. Sanderson, Drs. Appleby and Sanderson contacted workers in other states to see if other specimens had been collected before or after the original discovery. To their surprise, one correspondent reported that several individual beetles of this species were collected in Ohio in 1898 but were never reported.

Now that we have information on at least one host plant that the beetle feeds upon and we know that it occurs in three and possibly more states, it should be possible for insect collectors to be at the right place at the right time to find additional specimens. In this manner the life history, distribution, and economic importance of this species can be determined.

Without knowing where and when the beetles are present, it may have been many more years before other individuals were collected. The same is true for many other so-called "lost" species of plants and animals.

Where Do All the Little Fishes Go?

It is common knowledge that fish reaching adult size in lakes and ponds represent only 1 percent or less of all the fish that are hatched. Some of the young fish, called fry, probably die of starvation before they

Adult beetles of the "lost" species, *Phloeotribus scabricollis,* feeding at the base of a leaf petiole on wafer ash. (Photo by Survey photographer Wilmer Zehr.)

begin active feeding; some die of disease or pollution; others are attacked and eaten by various predators. One of these predators is the largemouth bass.

The effect on fry and fingerling populations in lakes from largemouth feeding is not well understood. Examinations of bass stomachs in waters where the bass is the only predatory species of fish have usually shown that many bass stomachs are empty or contain one or two fish, rarely more. Bass, of course, eat other animals including crayfish, frogs, and insects; but the lack of fish remains in their stomachs seems peculiar.

Recognizing that current information on bass feeding is inadequate, Survey aquatic biologist D. F. Hansen set out trotlines at Lake Glendale in southern Illinois to collect fish near shore and in open water. Examinations were made of the stomach contents of bass and bluegills taken at both locations to see what the fish were eating. The bass, which nearly all measured from six to ten inches and which could have eaten two- to four-inch sunfish, were found to have eaten large numbers of sunfish fry. These fry were only a few weeks old and measured one-fourth to one-half inch in length. They were especially common in the stomachs of bass caught in the middle of the lake, averaging eighteen to thirty-five per stomach, depending on the year; whereas they averaged only three to six per stomach in bass caught near the shore. The heavy consumption of fry by bass in open water is surprising since bass are usually thought of as shore line feeders.

Subsequent collections of fry throughout the lake with a large plankton net showed that fry were nearly as abundant near the shore as in open water. It appeared, therefore, that many bass had moved to open water to feed on the fry, possibly because the fry, in the absence of weed cover, were easier for the hungry bass to catch.

The largest number of fry, 213, were found in a nine-inch bass. No small fry have been found in bass over eleven inches in length caught by anglers at Lake Glendale, but occasionally large numbers of fry have been found in bass under ten inches caught on flies or plugs at the edge of the lake.

It has now become clear for the first time that the heavy predation on sunfish occurs when the sunfish are one, two, or three weeks old and that the really heavy predation by bass is done before the bass reach a size that interests sport fishermen. Dr. Hansen feels that the sunfish fry eaten in such large numbers by the bass are either bluegills or warmouth, but fry of this age are extremely difficult to identify. Efforts are now being made to identify the species positively by a biochemical method.

It would be interesting to know if this predation by small bass in open water occurs in all of our artificial lakes. The bass that fed so heavily on sunfish fry at Lake Glendale were rather undersized for their ages, which indicates they may have been eating the fry out of necessity because other foods were scarce. It is obvious that the fry were not providing the bass with a good growth diet.

Further studies should shed even more light on bass feeding in lakes and its effect on sunfish populations.

Imported Corn Leaf Aphid Parasites

The application of insecticides is only one method of controlling insects harmful to crops. Predators and parasites of economic insects can be quite effective in keeping insect populations at manageable levels and are being used increasingly to reduce the amount of insecticide required for adequate insect control. Since many of our crop plants are also grown in other countries, the United States Department of Agriculture employs teams of parasite hunters overseas who look for predators and parasites that attack insect species which cause crop damage in this country.

The corn leaf aphid — a small, soft bodied, dark-colored insect — has been a pest of corn in Illinois for many years. These aphids first appear in the whorls of corn leaves before the plants tassel out and occasionally become so numerous that they almost completely cover the tassels and upperleaves of the plants. They suck sap from the plants, sometimes causing a yellowish or reddish-yellow mottling of the leaves, which may later turn brown and die. They

may also cause stunting and shrivelling of the corn ears.

These aphids appear in Illinois cornfields in July and may be found until frost or until the corn matures and dries, thus removing their food supply. As many as nine generations have been reported in a single season in Illinois.

Lady beetles, as well as other predators and parasites, attack these aphids in Illinois but are not always successful in keeping the aphid populations below harmful levels. As a consequence, when parasite hunters in Europe — including former Survey entomologist R. J. Dysart — found a tiny wasp, *Ephedrus plagiator,* parasitizing corn leaf aphids, they sent aphid specimens containing parasites to the United States. Eventually one hundred specimens were received by Survey entomologist C. E. White, who then began rearing more parasites in the laboratory for study and for release of small colonies in Illinois.

A total of 336 adult female and 737 adult male parasites were produced in the laboratory and released in a cornfield near Urbana between July 21 and September 16, 1970. Aphids were collected from the field each week between the first and last releases. These aphids were then kept under observation to see if they were parasitized by the wasp. Parasites were found in aphids collected August 25 and September 8; therefore, reproduction did occur in the Illinois cornfields. Whether this colony of parasites was able to survive the rigors of an Illinois winter is still unknown, since the first few aphids of the season are just now appearing in Illinois cornfields.

Dr. White and his assistant, Sally Kerlin, will be eagerly collecting aphids from this field again this summer to determine whether or not the parasites survived the winter, a key factor in the potential value of the wasp as an aphid parasite. Laboratory studies on the wasp are continuing, and additional colonies will be released this summer if corn leaf aphids appear in significant numbers.

This study is only one of many being conducted by scientists at the Survey to make greater use of biological insect controls and help reduce contamination of our environment by pesticides.

Biochemical Insect Identification

The fall webworm, *Hyphentria cunea,* is a common tree defoliator native to North America. This colonial, web-spinning insect produces unsightly webs or nests that appear mainly on wild cherry and mulberry in the late summer and early fall. In Illinois, two distinct larval races occur: the orange-headed race with orange-colored head capsules and tubercles, and the black-headed race on which the head capsules and tubercles are black. Other factors such as seasonal emergence, nesting characteristics, feeding behavior, and host plant preference are also different for each race. The orange-headed race comprises 95 percent of the total fall webworm population in Illinois.

Webworm larvae produced by crossing the two races in the laboratory resembled the black-headed parent. Since only 5 percent of the larvae collected in the field were black-headed, it appears that crossing between the races in Illinois, if it occurs at all, is rare. To date, it has not been possible to distinguish between adult webworm moths of the two races for the lack of a reliable taxonomic character; therefore, the true status of these two so-called "races," taxonomically, remains in doubt.

Recently, Survey entomologists D. K. Sell and G. L. Nordin have been investigating the use of variations in isozyme patterns as a method of distinguishing larvae and adults of the two races. Isozymes are different molecular forms of a particular enzyme which can be separated and identified chemically. Research with isozymes has revealed that isozyme patterns can be used to distinguish species and races of animals. They also give a good indication of the genetic and evolutionary relationships between closely related animal populations. The study of isozyme patterns has thus become an exceedingly valuable tool in research on population genetics.

Results so far indicate that larvae of the two webworm races possess distinct patterns for isozymes of the enzyme esterase.

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Although isozyme patterns for adult webworm moths have not as yet been defined, adults collected in the field have been placed in liquid nitrogen storage for future use when this information has been obtained using laboratory-reared adults of known parentage. Previous experiments have shown that liquid nitrogen storage is not detrimental to the detection of these isozymes.

The Survey entomologists hope eventually to use this technique to determine how much, if any, crossing of the two races occurs in field populations of fall webworms by comparing the larval and adult esterase isozyme patterns with those of laboratory-reared individuals of known parentage. Studies such as this can be very useful in gaining knowledge of insect pest populations and, ultimately, in developing pest management systems.

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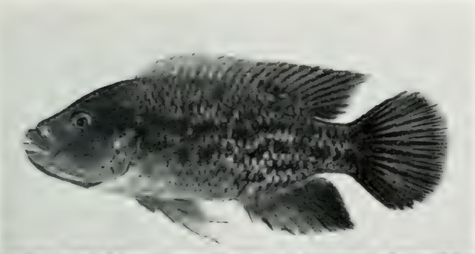
Aquatic Vegetation Control

One nuisance problem that lake and pond owners have to contend with is excessive vegetation. Herbicides are available that will control most algae and rooted aquatic plants without being toxic to fish. But herbicides are expensive and must be applied at the right time to give maximum results; and their benefits are temporary, often lasting only a few days or weeks.

In an aquatic ecosystem excessive vegetation is prevented by disease, parasitism, or by grazing of herbivorous aquatic animals. These organisms, ranging in size from viruses or bacteria to the American moose, are obviously not present in sufficient numbers or not dispersed widely enough to do the job.

On a worldwide basis, several animals have been introduced for vegetation control such as tropical sea-cows, South American nutrias, ducks and geese, several kinds of fishes, a South American snail, and a Russian chrysomelid beetle. Among introduced fishes are the Asiatic white Amur or grass carp, the Indonesian tawes, several kinds of African tilapias of which *Tilapia mossambica* may be the most commonly introduced, the Indonesian gorami, and an Asiatic race of carp called the Israeli carp.

Imported biological agents have great appeal: they reduce the problem through natural processes; their feeding is contin-



Above is a specimen of *Tilapia mossambica* (photo by Dr. William F. Childers). Below, biologist Larry Page holds a thirty-four-inch grass carp caught in the Mississippi River at Chester by commercial fisherman Paul DeSherlia. (Photo by staff photographer Wilmer Zehr.)

uous, eliminating expense of retreatment necessary with chemicals; and there is no danger of chemical contamination of the environment. The main unanswered questions in connection with introduced biological controls are: to what extent is the organism going to compete with native aquatic animals; will the reproductive potential of the alien allow it to outstrip its competition in the new environment where its natural checks and balances are probably absent; what impact will this organism have on the habitat when the nuisance vegetation is used up and it must turn to other food or starve; and does the imported animal have habits which might be worse than the vegetation to be controlled?

During the summers of 1962–65 Survey biologists, William F. Childers and George W. Bennett, studied the effectiveness of the tilapia in the control of algae and fine-leaved pondweeds in Arrowhead Pond in the University of Illinois' Allerton Park. Varying numbers of tilapias were stocked in early summer with varying numbers of largemouth bass (see *Journal of Wildlife Management,* Volume 31, Number 3, 1967); and each fall the pond was drained and a census made of the bass, tilapias, bullfrog tadpoles, and crayfish. Some tilapias were moved indoors for the winter. From these studies, it was estimated that one thousand tilapias of assorted sizes per acre would control the vegetation problem in Arrowhead Pond. (During 4 months in 1962, 10,800 per acre were produced from 58 small tilapias stocked in June.) Being of tropical origin, the tilapias die from cold each fall and thus present no permanent contamination. Numbers of tilapias are limited by strong bass populations unless bass predation is buffered by the presence of other kinds of fish. Thus if vegetation control is a primary objective, measures must be taken to insure production and survival of enough tilapias.

The white Amur or grass carp can withstand low water temperatures. A twenty-one-pound specimen was taken recently in the Mississippi River in southern Illinois. No one knows its potential nuisance qualities, the competition it may offer to native fishes, or even if it successfully reproduces in our waters. Distribution of grass carp should be restricted until more is learned about its behavior in American waters.

Nighttime Bird Migrations

The migration of birds southward in fall and northward in spring has excited the imagination of many people for decades. One difficulty of studying these migrations is the fact that many birds, especially smaller ones, migrate only or principally at night and are, therefore, difficult to observe. Many questions involving their flight patterns and densities during migration and the effects of weather conditions on their flight are difficult to answer because of darkness.

Frank C. Bellrose of the Survey's Wildlife Section has recently published a paper in the journal *Auk* on the distribution of nocturnal migrants in the air space. Flying in a small four-passenger aircraft cruising at 120 miles per hour, equipped with a standard landing light on the nose and two additional landing lights on the landing gear struts, two persons made observations of birds made visible by the landing lights while a third person recorded the observations. Both altitudinal and geographic transects were made.

Little difference in altitude was observed between spring and fall migrations. In spring 50 percent of the birds between ground level and five thousand feet occurred at the five hundred- to one thousand-foot levels, and in the fall 48 percent of the birds were at those levels. Few small birds flew over five thousand feet. Cloud cover made little difference in this distribution. Nor did wind conditions change this altitudinal distribution, although less than half as many birds were aloft when the winds were adverse at departure than when the winds were favorable.

Interesting observations on geographic distribution were made during this study. The density of migrants aloft increased from east to west from four miles east of the Illinois River valley to six miles west of the valley. Even though the axis of the valley coincides with the direction of mi-

Light plane showing landing lights and accessory lights on landing gear used to observe nighttime migrating birds. (Photo by staff photographer Wilmer Zehr.)

gration, there was no indication that the volume of migration increased along the Illinois River or its valley as if it were used for guidance. Several extensive surveys in the Midwest showed small birds moving on a broad front, which early in the evening appeared to be more related to the distribution of woodlands than to watercourses. One front of migrants extended at least 390 miles between Pekin, Illinois, and Lincoln, Nebraska.

On several nights when turbulent and smooth air were in well-defined strata, the observers were surprised to find most birds in the turbulent air even though the smooth air strata prevailed at altitudes well within their range of flight.

Baits for Cutworms

Economic entomologists are constantly experimenting with new and better methods for controlling insects and increasing our food production capacity. This can be accomplished with new insecticides, new applications of presently used insecticides, or utilizing another agent to increase activity or provide a better formulation. Presently, the insecticide evaluation team at the Illinois Natural History Survey is most interested in baits as agents to increase insect control of such major pests as black cutworm, fall armyworm, and corn earworm.

Baits are an old method used successfully several years ago but not attempted again in the Midwest until recently. Insects are specifically attracted to the bait and killed when they ingest the toxicant. The standard spray method, which is in common use today, deposits toxicant on soil and plant parts, and the insects must crawl on it or accidentally eat it to be killed by the spray deposit. For insects that are difficult to control, such as black cutworms, the bait approach to control will mean that Illinois farmers now have a reliable method to protect their young corn from devastation by these voracious larvae.

Ralph Sechriest, Survey Entomologist, has been testing many products for use as effective attractants for the baits. Several products have been evaluated such as corn meal, molasses, apple pomace, wheat bran, citrus meal, citrus pulp, grits, alfalfa meal, corn oil, mineral oil, lemon oil, and corn cobs. Various combinations have been tested on black cutworms and some have been made into a pellet. Most of these products are attractive to the black cutworms, but corn meal displays the most promise.

Pellets or granules can be made to any size desired. Four different sizes of baits were evaluated under greenhouse conditions using black cutworm larvae, which were the size normally found damaging corn. A large granule of 10/20-mesh size or a small pellet one-eighth of an inch thick by three-eighths of an inch long was found to be most effective. The pellet

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probably would be most satisfactory for field use because it would have a longer residual attractiveness.

Most toxicants will kill the black cutworms when eaten by the larvae. Dr. Sechriest has tested many insecticides and biological control organisms that result in disease and death of the larvae. Insecticides have been the only practical method of control that has been satisfactory thus far. The insects do eventually die from the diseases, but death occurs after the economic damage has already been done. Insecticides provide quick kill of the insects and thus save the farmer's crop.

Many new methods of insect control are being attempted. This year Illinois corn farmers began the use of bait for black cutworm control. Hopefully, more uses can be found in the near future.

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Much Maligned Hawk

The sharp-shinned hawk, with the Latin name *Accipiter velox,* is often called a chicken hawk along with several other hawk species. It can be found in Illinois year round but is most common in the spring and fall when it migrates through the state. It is the smallest of the three species of Accipiter hawks that prey primarily on other birds.

Until recent years, the sharp-shin has had a reputation among farmers, sportsmen, and bird watchers as the personification of evil in the bird world — a killer of chickens and our beloved small songbirds.

In the late 1800's, sportsman-author C. W. Nash wrote the following description of a sharp-shinned hawk attack: "On one occasion an impudent villain of this species glanced past my head and snatched up a plover I had shot, carrying it off in front of my dog's nose, and this he did before the report of my gun had died away, and through the smoke from the charge."

This seems quite a feat of daring for a bird, a boldness that could easily be admired, but apparently not by Mr. Nash who continues: "The act so astonished me that I forgot to shoot at him until he was too far off; when I did remember, I sent the other shot after him, but without effect; he did not even drop his ill-gotten spoil." As for the plover, if he was healthy he probably would have had a better chance against the hawk than the gun, which is less discriminating.

In contrast to this vehement description, observations made recently by Survey wildlife specialist W. W. Cochran of sharp-

A sharp-shinned hawk fitted wih miniature transmitter for radio tracking. (Photo by University of Illinois astronomer George Swenson.)

shinned hawk behavior indicate that this bird is certainly not the threat to poultry farmers and bird lovers that folklore decrees. In conjunction with radio-tracking studies, Mr. Cochran fitted two sharp-shins with miniature radio transmitters and followed their movements as they migrated through Illinois in October 1970.

The first hawk was released near Urbana and observed almost continuously until its radio failed near Sturgis, Kentucky, on October 13. Although the hawk spent several days each in the vicinities of Urbana, Newton, Olney, and Shawneetown, it never came near farms or towns but instead kept to extensive wooded areas with heavy vegetation along creeks and rivers. Wherever houses were located adjacent to woods, the hawk detoured around them. After the second hawk was released near Urbana, it was followed for thirteen days until it was lost near Vincennes, Indiana. The closest this bird got to a farm was a row of trees one-eighth of a mile away near Fisher, Illinois.

Migratory flights of these birds were observed only on days with a north wind and then only during midday when the vertical air currents or thermals were favorable for easy flight. The greatest distance covered in a single day by either of these birds was about 70 miles although another sharp-shinned hawk was tracked on a spring day from near Urbana to the vicinity of Sterling, a distance of some 140 miles. Mr. Cochran's observations indicate that the reputation of the sharp-shinned hawk has likely been founded either on observations of exceptional behavior or on mistaken identifications of the similar but larger Coopers' hawk.

Insulating Plant Roots With Mulches

Mulches are commonly used on woody plants to conserve soil moisture and to insulate tender crowns and root systems against damage by freezing. Little information is available, however, on the relative effectiveness of different kinds of mulches as insulating materials. A thorough study of mulches is needed, particularly as to their value for use on newly transplanted trees and shrubs.

Since woody plants are weakened as a result of transplanting shock, significant damage due to freezing stresses is often experienced on newly transplanted specimens. With this in mind, Survey plant pathologist E. B. Himelick recently initiated a research program to evaluate the merits of different mulches in preventing freeze injury. Peat moss, ground corn cobs, and a mulch known as Krum were placed as mulches, four inches deep, around trees in the Survey's experimental nursery. Soil temperatures at several levels in unmulched ground and under the various mulches were recorded at intervals during the winter and spring of 1970–71.

Although the soil in the Champaign-Urbana area was not frozen at the 6-inch depth until January 5 this past winter, by February 16 the depth of frost was 13.8 inches without mulch, 7.3 inches under peat moss, 6.2 inches under Krum, and 3.5 inches under corn cobs. Unmulched soil at the six-inch depth remained frozen until March 4, after which soil temperatures under all mulches used tended to remain colder than unmulched soil until May 27. A more extensive test will be conducted this coming year using additional types of materials commonly used as mulches.

Since roots will continue to grow after leaf drop as long as soil temperatures remain favorable, mulches applied in early fall should help promote a more rapid root system development. In the spring, the insulating effect of the mulch should prolong cold hardiness and lessen the chances of injury due to late freezes on sensitive plants. The present study will hopefully provide useful information on which mulches and mulching techniques will be of greatest value in reducing freeze damage on newly transplanted trees and shrubs.

Western Corn Rootworm Moves In

In recent years corn rootworms have become a major insect problem confronting Illinois corn producers, particularly in the northern half of the state. During August, adult rootworm beetles lay eggs in cornfields. These eggs hatch into larvae the

Corn rootworm damage. Plant on the left shows severe damage from an untreated field, those on the right show several degrees of control achieved with insecticides. (Photo by Dr. R. E. Sechriest.)

following June and early July, and corn is damaged by the larval stages feeding on the roots. The problem has been complicated by the fact that two species of rootworm are now present, and both are resistant to the chlorinated hydrocarbon insecticides. Man has greatly favored the rise in rootworm populations to levels of economic importance by planting extensive acreages of corn and even more so by cropping corn continuously on the same land year after year.

Although the northern corn rootworm has been a pest in Illinois for many years, the western corn rootworm is a relative newcomer to the state. The western species was first found in Rock Island County in 1964 and has since spread to fifty-four counties in the northern half of the state. As this species spread eastward and southward, rootworm population pressures increased around the periphery of the infestation while populations have declined to a slight extent in the older areas of infestation such as Mercer, Rock Island, and Henderson counties. The highest populations of the western species presently occur north and west of a line from Carthage to Peoria to Woodstock. Adults of this species were collected as far south as Shelby County in south-central Illinois this past summer.

Keeping track of economic insect populations and aiding in the development of control measures are some of the many duties of Survey extension entomologist D. E. Kuhlman. For the past seven years, Dr. Kuhlman has made a rootworm population survey during August in Illinois when the adult rootworm beetles can be trapped and counted. Data collected from these surveys indicate that there has been a gradual increase of the western species and a decline in abundance of the northern species in the state. In 1971, western corn rootworms comprise 37 percent of the adult rootworm population in northwest Illinois, 38 percent in the northeast, 27 percent in the west, and 9 percent in central sections of the state.

The fact that both species are resistant to the chlorinated hydrocarbons means that farmers confronted with severe infestations of corn rootworms must either discontinue continuous cropping of corn on the same land or apply organic phosphate or carbamate insecticides for rootworm control.

Pin Oaks — Green or Yellow

The leaves of woody plants occasionally turn yellow or chlorotic during the growing season from a variety of causes. These may include drought, flooding, disease or insect damage, chemical injury, pollution, or nutrient deficiencies. The most common type of chlorosis in Illinois is caused by iron deficiency, resulting from alkaline soil conditions. Some plant species, particularly pin oak, are unable to obtain an adequate supply of iron from alkaline soils.

When pin oaks become chlorotic, the treatment most often recommended is to apply iron-containing compounds to the soil. Since alkaline soil is nearly always responsible for the chlorosis, acidifying materials such as sulfur or aluminum sulfate are often added. In some cases these treatments have been effective but in many instances chlorotic trees have failed to respond to soil treatment. Whether the

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treatments were not applied properly or whether trees in advanced stages of chlorosis are incapable of responding to soil treatment is a question that has been debated for years.

To settle this controversy, Survey plant pathologist D. F. Schoeneweiss set up a series of field tests utilizing several iron-containing compounds and soil acidifying materials. These were applied in both dry and liquid form to alkaline soil beneath pin oaks exhibiting advanced stages of chlorosis. Results of these tests were suprisingly clear cut. All trees treated with iron compounds known as chelates were restored to a healthy green color. Liquid injection with a root needle gave response within two weeks, whereas dry application required several months before treated trees began to turn green. No other treatments, including large doses of iron sulfate, sulfur, and fertilizer, provided any correction of chlorotic symptoms.

Since pin oak chlorosis is nearly always associated with alkaline soil, Dr. Schoeneweiss feels that chlorosis problems could be greatly reduced by planting pin oaks in acid soil and avoiding alkaline soils, which can be detected with a simple soil test. Unfortunately, this is seldom done. When pin oaks are planted in alkaline soil and iron chlorosis results, the condition can be corrected, even on severely chlorotic trees, by soil application of chelated iron compounds. These compounds are available under various trade names and should be applied at rates recommended by the manufacturer. Best results are obtained by either placing the materials dry in holes bored into the soil beneath chlorotic trees or injecting the materials in a water solution with a root needle. Although chlorotic trees can be treated at any time, soil applications in early spring are usually more effective.

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Soybeans, Alfalfa, and Pests

Soybeans, a major Illinois crop, do not suffer from a major insect pest in this area comparable to corn ear worms or corn root worms in corn. Why is this? According to Survey entomologist Edward Armbrust, it may be because a reservoir of parasites and predators are maintained on the potential soybean pests in alfalfa and clovers grown extensively throughout the state. Such an equilibrium of pests, parasites, and predators on two or more crops provides us with a complex ecosystem which should be studied in order to provide information useful to solving future pest problems and problems of pests in other areas where such a balance is not maintained.

Alfalfa provides a reservoir for many pests of both alfalfa and soybeans because alfalfa is a perennial crop and the insects are maintained over winter and from year to year in alfalfa fields. Likewise, the perennial alfalfa provides a reservoir for insect parasites and predators of the pests affecting both crops.

In studying these interrelationships, six pest species (yellow-striped armyworm, alfalfa caterpillar, variegated cutworm, green cloverworm, clover looper, and the wooly bear) have been studied intensively. With these six pests, 10 to 12 common hymenopterous and dipterous parasites have been noted. Early in the season about 10 percent of these pests in alfalfa are parasitized. Late in the season up to 100 percent of the pests in a field may be parasitized. Throughout the season, in both alfalfa and soybeans, an average of 60 percent of these six pests are parasitized. Thus, spraying alfalfa and clovers or destroying these crops at the wrong time in the vicinity of soybean acreages could presumably cause a depletion of parasites and an increase in the pests in the soybeans.

During these studies it was found that two species of thrips common to both alfalfa and soybeans did not overwinter in Illinois. They were found overwintering in Louisiana and Texas and first appeared in Illinois in roadside legume plantings. Later these thrips moved into alfalfa fields and still later in the season into soybean plantings. The thrips are being studied by Survey entomologists L. J. Stannard and Ed Armbrust by means of flight-traps, sweeping, picking of leaves, and other methods. The distribution of the insects in the field, in

First known photograph of the cocoon of *Aeolothrips fasciatus*, a thrips predator of plant-feeding thrips found on the soybean-alfalfa complex. (Photo by Survey photographer Wilmer Zehr.)

the state, and on the plants is being investigated, together with predators of the thrips and their populations and habits.

These studies are expected to provide us with some insight into what influences movements of insects. They should be instrumental in helping to devise recommendations not only for spraying insecticides, but for timing of control measures, of planting and cutting crops, and should aid in dealing with future introductions of pests of soybeans and their parasites and predators.

Computers, Pests, and Biological Control

Most people agree that biological control of agricultural pests would be preferable to chemical sprays, but the lack of workable biological control programs in almost all cases leaves no alternative. Except for the hit-and-miss approach to biological control, the actions and interactions among pest, predator, and parasite populations are not understood well enough for a biological control program to be successful. This is due primarily to the great complexity of the interactions occurring between the populations of pest and parasite species. The theoretical and mathematical approach to population interactions has been consistently limited to two species at most, although the average number of species of insects in a soybean or corn field may reach as high as several hundred. The advent of high speed computers and several new numerical mathematical techniques now makes it possible to investigate population interactions among several species, not just two. With a number of species, the number of possible fates of the prey and parasite species becomes almost infinite, depending on the characteristics of the populations, such as initial numbers of each species, birth and death rates, and in great part just pure chance.

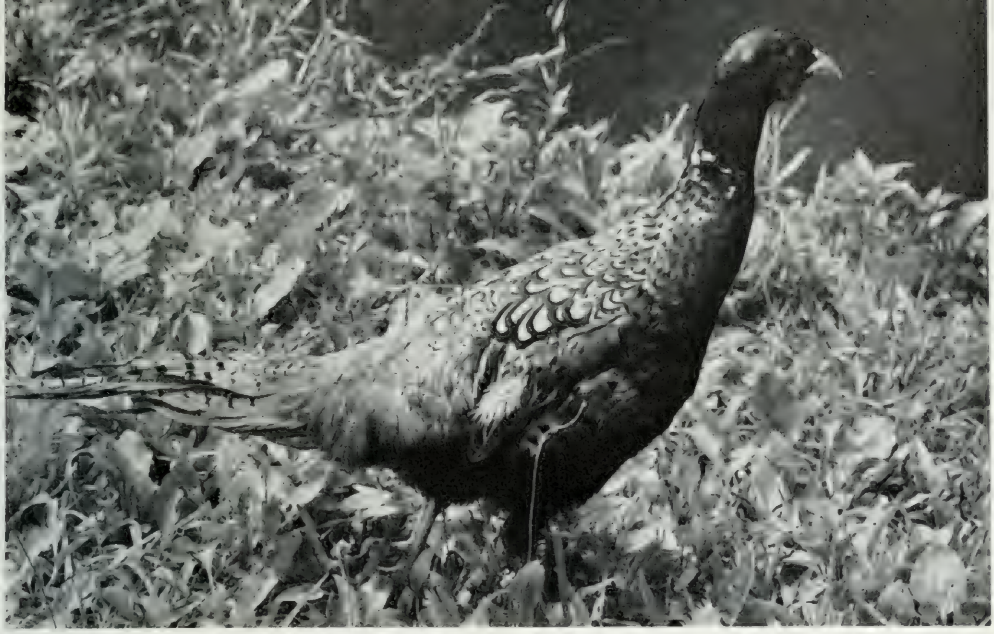
Robert W. Poole of the Faunistics section has been investigating population interactions among groupings of several prey species and parasites. The most realistic models are those taking into account the influence of chance, one of the most important determining factors in population ecology. Using equations including chance and a numerical method called Monte Carlo techniques, named after the famed casino town, these equations are programmed for a computer and the millions of calculations needed can be performed in minutes rather than the years necessary if the calculations were done by hand.

Some preliminary results are rather surprising. The best parasite to introduce to reduce the numbers of some pest or several pests is usually not the most voracious parasite, but the least voracious. A voracious, efficient parasite causes large fluctuations in the prey population, eventually causing its own extinction, while the inefficient, poor parasite by its sloppiness never catches enough of the prey to endanger its own food source. Another unorthodox finding suggests that the pest damage in a field may in some cases be lowered by introducing a second pest species. The possibilities become almost endless as the number of pests and parasites increases. Usually there are several possible methods of reducing pest populations if there are a large number of species.

Once the complex species interactions are understood and confirmed experimentally, statistical models can be created to fit the situations. Perhaps in the distant future it will be possible to create computer programs that will digest data on the densities of each species of insect in a field of corn, analyze the data, create the correct model to fit the situation, and recommend parasites or predators to be added to aid in keeping a pest species at a reasonable, economic level. However, even if this approach is possible, it will not come for many years. Pest and parasite population fluctuations in a crop are perhaps the most complicated and least understood aspects of biology. Ecology is a long way from understanding populations well enough to manipulate whole communities of plants and animals for its own ends.

Pheasants and Chemical Elements

Why pheasant populations are higher in one area than another is of great interest to wildlife management personnel and, of course, to hunters. Thriving populations of pheasants in Illinois are usually confined to



Cock pheasant in the field in Illinois. (Photograph by Survey photographer Wilmer Zehr.)

recently glaciated soils in the northeastern third of the state. Survey wildlife biologist William L. Anderson, and Peggy L. Stewart of the University of Tennessee Department of Physics have studied five major and 19 trace elements in relation to the distribution of pheasants in Illinois (*Journal of Wildlife Management*, 1969).

Concentrations of the 24 elements were studied in soil, grit, corn, and tissues of pheasants from good (Sibley), fair (Humboldt), and poor (Neoga) pheasant ranges. The Sibley area is more or less centrally located in the area glaciated by the last (Wisconsin) ice sheet; the Humboldt area is near the edge of this glaciated area; and the Neoga area is outside of the glaciated area. Pheasants are relatively abundant at Sibley, intermediate in abundance at Humboldt, and low in abundance at Neoga.

Many area-to-area differences in elemental concentrations in pheasant tissues, soil, grit, and corn, found during this study make it difficult to discount any element as being unimportant in limiting the distribution of pheasants. However, of the elements studied, suspicion is directed toward calcium, magnesium, potassium, chromium, cobalt, and molybdenum as possibly being important in Illinois. The concentration of the first three (major) elements in both soil and pheasants was found to be greatest at Sibley, intermediate at Humboldt, and least at Neoga. The remaining three (trace elements) are suspected of having an influence on pheasant distribution because they are biologically active; they showed area-to-area differences in concentration in at least two of three pheasant tissues, these differences were directly related to those in grit from soil; and concentrations of chromium and molybdenum increased with increase in age of birds in the Neoga area.

If inorganic ions are limiting the distribution and abundance of pheasants in the Midwest, combinations of two or more elements, and not individual elements, are probably involved. Interactions between elemental ions possibly differ from area-to-area and need to be studied further.

Ecology and Livestock

In recent years, confined livestock rearing systems have become popular. These systems result in large amounts of organic wastes on small land areas, representing large concentrations of unused nutrients and a serious pollution threat to air and surface waters. Survey biologists John Tranquilli, W. F. Childers, and G. W. Bennett have arranged to use several lagoons on the University of Illinois swine farms to determine whether useful by-products (such as fish protein and sport fishing) can be produced in these polluted waters.

Tremendously large populations of mos-

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quito larvae and pupae occur in these ponds between mid-July and mid-October. At least one of the dominant mosquito species constitutes a public health hazard because it is a vector for human encephalitis. In order to control the mosquito populations during the summer of 1971, it was necessary to treat the ponds with fenthion (baytex) at two-week intervals.

Several physical factors were monitored at two-week intervals in the three largest lagoons. Lack of dissolved oxygen seems to be the major limiting factor for the production of fish in these lagoons. In the three lagoons tested, the dissolved oxygen reached supersaturated levels during the day. In two of the lagoons, the dissolved oxygen fell to zero during the night, but in the third lagoon it usually did not fall below 2 ppm. Several species of fishes placed in cages in this third pond were able to survive for several weeks.

An attempt is now being made to acquire aeration systems for these ponds, so that fish might be maintained in them. Since the ponds are very rich in nutrients, fish production should be extremely high. Many species of warm-water fishes feed voraciously on mosquito larvae, and if it were possible to rear fish in the ponds, the mosquito health hazard would be eliminated.

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Baldcypress Twig Gall Studied

The baldcypress is becoming more popular as an ornamental tree throughout the state since it is now known that the tree will grow in many different soil types other than its native river bottoms in southern Illinois. Although this rapid-growing tree has the appearance of an evergreen because of its needle-like foliage and straight, upright trunk, it is actually deciduous and drops its needles in the fall.

This species is relatively free of disease and insect pests except for the cypress twig gall, to which most baldcypress are susceptible. The twigs may be so heavily infested with the galls that the limbs actually droop. Infested trees have been found from central Illinois southward and the insect that causes the gall has been reported in Louisiana and Tennessee.

The typical gall is about three-quarters of an inch long and green in color, turning brown in fall. During the winter months, the galls are found on the soil surface beneath the tree. Inside each gall may be found as many as fifteen yellow-orange larvae of an insect known as a midge. In late April, the larvae change into the pupa stage, and in early May the tiny mosquito-like flies emerge from the galls. The adult female fly lives for only a few days, but be-

A severe infestation of twig gall on baldcypress in southern Illinois. (Photo by Survey assistant photographer Lee Trail.)

fore her short life span is over, she will deposit an average of 170 light yellow-orange eggs on the unfolding cypress leaf buds. The female fly excretes a gelatinous substance during egg-laying which helps the eggs to stick to the foliage. The larvae hatch seven to ten days later and are only about one-tenth of an inch long. They congregate in the growing branchlet tips and begin feeding. Soon the branchlet begins to swell and eventually covers the larvae, forming the typical gall.

In 1971, Survey entomologist C. Chen began a detailed life-history study of this insect, since no such study had ever been conducted previously. To date, he has found that the adult flies are abundant on the trees during three periods of the growing season. He also found that the 1970 overwintering gall midge population was about 70 percent parasitized by three different species of parasites.

At present it appears there may be two ways to control this insect, other than by the use of chemical pesticides. One way is to take advantage of natural parasites. The other is to grow resistant clones of trees that are not attacked by the gallmaker. In 1968, Survey entomologist J. E. Appleby observed several trees in southern Illinois that lacked galls entirely. These trees were growing next to trees heavily infested with galls. Dr. Appleby took branch cuttings from both resistant and infested trees and propagated them under greenhouse conditions. In the spring of 1970, after the trees were well-established in outdoor containers, he placed numerous galls containing overwintering larvae adjacent to the tree trunks. The midge adults emerged from the galls and began egg-laying. As was expected, the resistant trees developed no galls, whereas the susceptible trees became heavily infested. In studies conducted in 1971, Mr. Chen observed that the female gall midge does not lay eggs on the resistant trees.

Further studies are now planned to gain more detailed information about the life history of this insect and about the life histories of its natural parasites as well as their importance in control.

Cottontail Decline

Until the last few years, the cottontail rabbit has been Illinois's number one game animal in terms of recreational hunting and quantity of meat harvested. In the early 1960s, rabbit populations over much of Illinois began a major decline. This decline is still going on with only a few scattered instances of population increases to anything approaching former abundance.

To determine possible relationships between declining rabbit populations and Illinois agriculture, Survey wildlife specialist William R. Edwards is in the process of evaluating two series of data on rabbit abundance which span fifteen years, 1956 through 1970.

The first series of data represents the estimated annual harvests of cottontails as determined from hunter questionnaire surveys conducted by Mr. W. L. Preno, biologist for the Illinois Department of Conservation. Multiple correlation analysis revealed that the annual state-wide population of rabbits was significantly correlated with the annual totals for harvested acreages of corn, oats, and hay. This data indicated that about 97 percent of the change in rabbit harvest was associated with the change in the acreages of these three crops. During the fifteen-year period, the acreage of corn in Illinois increased while the acreage of oats and hay decreased. The reduction in the production of oats was particularly significant in relation to rabbit abundance.

The second series of data represents fifteen years of counts of cottontails made during pheasant brood census on the Sibley study area in Ford and McLean counties. Again rabbit populations were closely correlated with acreages of corn, oats, and hay. In this analysis, the data indicated that about 93 percent of the variability in the counts was associated with the three crops, the acreage of hay being the most significant.

Mr. Edwards considers this data clear evidence of the dependence of cottontails on agriculture in Illinois and particularly on the production of oats and hay.

Farming in Illinois has changed dra-

Newly converted Survey field station designed for studies on the biology of the Kaskaskia River and Lake Shelbyville. (Photo by Warren Brigham.)

matically over the past fifteen years. Acreages of corn and soybeans have increased materially while acreages of oats and hay have declined. With this change in agriculture has come a major reduction in the ability of our farmland to support high-density cottontail populations. Every current indication is that the trend toward more row crops and less small grains and hay will continue. The data clearly indicate that as this happens, we can only expect fewer rabbits in Illinois. Although cottontails may in fact exhibit modest cyclic tendencies in their abundance, rabbit populations over the past fifteen years have been almost completely dominated by changes in farming over the vast majority of their range in Illinois.

New Kaskaskia River Laboratory

For more than seventy years Survey scientists have been studying the fishes of the Kaskaskia River. This work was intensified during the past ten years to include more detailed fish studies as well as studies of fish food supplies, invertebrate and algal communities, and water quality relationships.

People along the river have shown sincere interest, and sometimes amusement, in the activities of Survey biologists as they stun fish with electricity, grub insects from the sand and gravel, and strain drifting insects from the river currents. These workers come and go all hours of the day and night to get collections for what they hope will be one of the most complete studies ever conducted on a midwestern river.

The biologists are now seen less often around the Sullivan area because they have a new field station that provides a place to process collections, conduct laboratory analyses, store equipment, study, and eat and sleep. This station was established by the Illinois Natural History Survey in September of 1968 on the Kaskaskia River in Moultrie County, overlooking the headwaters of the new Lake Shelbyville. It consists of two houses, one converted into a well-equipped laboratory, the other converted into a dormitory for use by resident biologists and visiting scientists. The station includes 8 acres of surrounding land bordering the 3,500-acre upper Kaskaskia wildlife area.

The new laboratory is under the direction of Survey aquatic biologist R. W. Larimore. In addition, three resident biologists, Warren and Allison Brigham and Donald Dufford, each of whom have mas-

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ters degrees in zoology, are conducting research at the station. The Brighams have minors in sanitary engineering and are completing Ph.D.'s in zoology; Mr. Dufford has a minor in systems analysis and computer programming. The competence of this staff and the facilities now available have permitted much further development of research in aquatic communities and water quality evaluation, including water chemistry, pollution analysis, nutrient cycling, fishery biology, and invertebrate production.

Survey personnel are gratified by the interest that people along the river have shown in their studies, particularly as these studies relate to the effect of the Shelbyville impoundment on the fishes of the river and the ways of maintaining a fishable population in the lake in the coming years. With the establishment of this new facility, it is hoped that much needed information will be obtained through future research on the effects of impoundments and pollution on the plant and animal communities of fresh-water streams and rivers.

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JANUARY 1972, NO. 111

Game Statistics

How many cock pheasants are shot annually by hunters in Illinois? Where in the state are cottontails most abundant? Which Illinois county hosts the greatest hunting effort for small game? Answers to these questions can be found in the recently published Illinois Department of Conservation Technical Bulletin Number 4. The bulletin, entitled *Abundance and Harvest of Doves, Pheasants, Bobwhites, Squirrels, and Cottontails in Illinois, 1956–69,* was authored by Illinois Department of Conservation biologist William L. Preno and Survey wildlife specialist Ronald F. Labisky. The following highlights will serve to illustrate the diversity of information contained in this catalog of statistics on the abundance and harvest of upland game in Illinois.

The statewide pattern of abundance of Illinois's major upland game animals between the mid-1950s and late 1960s was as follows: bobwhites, substantial gain; gray and fox squirrels, modest gain; pheasants and doves, modest loss; and cottontails, substantial loss.

The combined harvest of doves, pheasants, bobwhites, squirrels, and cottontails in Illinois averaged 11,112,000 animals annually during the fourteen years, 1956–69, ranging from a high of 13,644,000 in 1956 to a low of 7,444,000 in 1965. Correspondingly, resident Illinois hunters averaged 5,589,000 hunter-trips for these species annually; the hunting effort, like the harvest, was greatest in 1956 — 6,291,000 hunter-trips, and least in 1965 — 4,360,000 hunter-trips.

The species composition of the annual harvest of upland game in Illinois for the fourteen years, 1956–69, averaged as follows: cottontails, 33 percent; gray and fox squirrels, 26 percent; bobwhites, 19 percent; mourning doves, 14 percent; and pheasants, 7 percent. The distribution of the hunting effort for these species for the same years averaged as follows: cottontails, 36 percent; gray and fox squirrels, 25 percent; pheasants, 17 percent; bobwhites, 14 percent; and doves, 8 percent.

Hunting success, all six species considered, averaged 1.98 animals per hunter-trip for the fourteen years, 1956–69; it was generally greatest in southern and southwestern Illinois, intermediate in central Illinois, and poorest in northern Illinois. Interestingly, 77 percent of all hunter-trips expended for upland game in Illinois and

Cottontail rabbit in snow under brambles. (Photo by former Survey photographer W. E. Clark)

74 percent of all upland game bagged were attributable to small-game licensees who hunted in the same county in which they resided.

Crop Pests in 1971

The twenty-fourth annual Custom Spray Operators Training School will be held January 25–27, 1972, in Urbana. During this session a report is presented to the participants dealing with insect pests and their control in Illinois during the previous year. This report, prepared by Survey entomologists Roscoe Randall and Donald E. Kuhlman, is a summary of data sent in by County Extension Advisors in agriculture. Each advisor received an average of 1,006 inquiries about pests in 1971, of which 677 concerned agricultural pests and 329 concerned home and garden insects. The most common insect pests reported, listed in decreasing order of importance, are: corn rootworms, grasshoppers, corn borers, wireworms, corn leaf aphids, cutworms, bagworms, alfalfa weevils, spiders, and roaches.

Field crops treated with insecticides in 1971 were similar to 1970. About 6,809,800 acres of field crops were treated with an estimated savings to farmers of $23,092,825 above treatment costs. Corn farmers reaped the lion's share of this saving. An estimated $21,179,278 is attributed to treating corn acreages with insecticides for controlling corn soil insects.

A sudden upsurge in the number of cornfields damaged by wireworms occurred in 1971. The greatest number of reports of damage came from the southern one-half of Illinois and were most common in fields that were planted in wheat in 1969.

First brood European corn borer populations in 1971 were generally low and caused minor damage. Although the 1970 overwintering populations were fairly low (state average of 85 borers per 100 plants) corn planting was earlier than usual and thus a situation was provided where infestations and survival of first generation borers might have been great. Fortunately this did not occur. There were large acreages of early planted corn in 1971, providing the moths with many places to lay eggs. The first generation was scattered over a large area with most fields having light infestations. Only a few fields required chemical control. Many fields did have some borers, and this added up to a big supply of moths to lay eggs in late-planted corn, and second-generation corn borer populations were higher in 1971 than in 1970. The state average is 130 borers per 100 stalks of corn.

Extended periods of dry weather were responsible for a buildup in two-spotted spider mite populations in central and west-central areas. Mites could be found on the undersides of lower leaves of corn plants along the margins of many fields. Damaged leaves turned yellow or brown. An occasional field was infested throughout and required treatment. Timely rains prevented damage by killing the mites; this allowed the plants to recover.

With a sharp increase in grain sorghum acreage this year, particularly in southern Illinois, there was reason to be concerned about insect damage to this crop. Fortunately the insect damage to grain sorghum was, for the most part, noneconomic. Many fields were heavily infested with corn leaf aphids. These apparently did not cause any economic losses. Greenbugs were observed in relatively few fields and were not a problem. Sorghum midges caused some concern; but again, damage was relatively minor. Corn earworms and sorghum webworms were found feeding in many fields, ranging in size from newly hatched to fully grown.

Man-made Marsh and Bass

The Survey has been conducting extensive investigations of floodplain pools and marshes along the Kaskaskia River for the past twelve years. Many fishes depend on these waters as breeding sites and production of young sport fishes and forage fishes in floodplain areas is very important to the fisheries of the river and associated reservoirs.

In order to apply the information gathered on the relation of floodplain pools to rivers and reservoirs, a 200-acre marsh was developed by the formation of three low levees next to the Kaskaskia River near the Survey laboratory near Sullivan. The principles of dynamic production observed in

Inundated marsh showing levees. (Photo by George W. Bennett)

the natural floodplain pools will be used to manage this marsh to improve fish populations and fish food supplies in the river and its mainstream reservoirs. Survey biologists R. Weldon Larimore and Don Dufford are leading this investigation. The marsh area was completed in December of 1970 and began filling the following March. Enormous populations of zooplankters developed, utilizing the accumulation of organic debris on the floodplain.

Sixty-five 1½- to 2½-pound adult largemouth bass were stocked in mid-April. Actual nesting of the bass was not observed in the newly-inundated bottomland fields, but by mid-June many fry could be seen. On June 14, there were fourteen large schools of fry along the lower levee adjacent to the river. Growth of these young bass was rapid. Mean total lengths of small samples were: June 16, 30 mm; June 30, 51 mm; and July 13, 59 mm. The largest bass fingerling measured in the July 13 collection was 95 mm, but many, much larger specimens were seen.

Heavy rains in mid-July filled the adjacent Lake Shelbyville, inundated the full 200 acres of marsh behind the levees, and even topped the levees in several places, bringing in great numbers of small gizzard shad on which the young bass fed. Mean length of bass collected August 17 was 169 mm, with the largest measured being 195 mm. It is expected that these young bass will attain lengths of more than 250 mm (10 inches) in this first growing season.

In spite of the difficulties imposed by the exceptionally dry spring and by the unusually heavy rains of early July, it was evident that large numbers of bass fingerlings can be produced in such an artificial marsh and released to supplement natural reproduction in an adjacent river or reservoir. It is estimated that one-half million large fingerling bass can be produced each summer in this man-made marsh at the Survey laboratory, enough to provide 40 per acre for all of Lake Shelbyville.

The value of such a management technique rests in its flexibility to the needs of the reservoir and in the small amount of manpower used. Until now, few effective plans have been suggested to overcome the collapse of sport fishing in large reservoirs that usually occurs after a few years. Proposed plans have called for huge expenditures of money and manpower. The plan outlined here would allow large introductions of fingerling bass in those years when reproduction in the reservoir proper was very poor because of competition of other reservoir fishes. Annual broods of sport fish could be established to support continuing fishing success.

Mississippi River Fishes

The mighty Mississippi River for the sake of administrative convenience can be divided into the lower and upper Mississippi. The lower section, between the mouth of the Ohio River near Cairo, Illinois, and the Gulf of Mexico below New Orleans, Louisi-

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ana, is meandering but navigable even though unimpounded and unchannelized. The upper section, between the mouth of the Ohio River and St. Anthony Falls near Minneapolis, Minnesota, is less meandering and navigable because of the twenty-six navigation pools separated by locks and dams in this stretch of the river.

Jurisdiction over the upper river is in the hands of a remarkable group known as the Upper Mississippi River Conservation Committee; it consists of representatives from the five states bordering the upper Mississippi (Minnesota, Wisconsin, Iowa, Illinois, and Missouri) and certain federal agencies. This dedicated group of biologists and engineers, who for more than twenty-five years have placed the welfare of the river above that of their own states, has representatives from two Illinois state agencies: the Natural History Survey and the Department of Conservation.

In recent years growing concern over pollution and habitat alteration in the Mississippi River prompted the committee to embark on a study of the present distribution of fishes in order to provide a criterion that might aid in the detection and measurement of future changes in the environmental quality of the river. Between 1962 and 1971 the member agencies, supervised by Survey ichthyologist P. W. Smith, cooperated with the Natural History Survey in censusing the 850 river miles between Cairo and Minneapolis. Thousands of fish specimens were sorted and identified and their distributions plotted by personnel of the Survey.

The results of this cooperative study are summarized in a recently published Biological Notes entitled "A Distributional Atlas of Upper Mississippi River Fishes" by Smith, Illinois Department of Conservation Fishery biologist A. C. Lopinot, and Missouri Conservation Fishery biologist W. L. Pflieger. Copies of this publication, which contains detailed distribution maps for most of the species, are available from the Illinois Natural History Survey upon request.

The authors found 134 species presently inhabiting the upper Mississippi River, 30 of which could be regarded as stragglers. They found that many of the fishes do not occur throughout the length of the river but have restricted and discrete ranges within the area. The authors reported that, despite the references to the Mississippi River as a sewer and the colon of mid-America, the river has an extremely rich fish fauna and good populations of most of the native species, only the musky having been extirpated in recent times. The authors also note that many species of fishes are less generally distributed than formerly and warn that constant surveillance by a conservation-minded public is needed if further deterioration of the environmental quality of this great river is to be avoided.

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Twig Blight Fight

Sycamore anthracnose is a fungus disease that affects both leaves and twigs of sycamores. Leaf blight occurs during the summer and results in little or no serious injury to the trees. Damage to twigs, however, may be injurious to the health of the tree as well as to its aesthetic appearance. Activities of the fungus in the twig may result in bud blight, twig blight, or shoot blight and portions of the twig or the entire twig may be killed.

Shoot blight, which appears after the shoots emerge from the buds, has been considered the most serious stage of sycamore anthracnose, and disease control has been aimed primarily at this stage. A properly timed application of organic mercury fungicide when buds are swelling in the spring will control shoot blight. This spray has little effect, however, on the twig blight stage.

Twig blight occurs in either fall or spring prior to the emergence of leaves. To see if organic mercury will control twig blight when applied during the dormant season, Survey plant pathologist Dan Neely set up a series of spray tests in 1969–70 and repeated the tests in 1970–71. Spray applications were made in the fall and spring and in the spring alone. Twigs from sprayed and unsprayed trees were collected, measured, weighed, and rated for twig blight damage.

The organic mercury fungicide greatly reduced the incidence of twig blight. In 1970, the spring applications reduced twig blight damage by 40 percent and the fall and spring applications reduced it by 90 percent. In 1971, the reductions were 35 percent and 85 percent respectively. This study confirms that twig blight occurs in both fall and spring and that the twig blight stage of anthracnose can be controlled by properly timed sprays of organic mercury.

Twig blight stage of sycamore anthracnose. (Photo by Dr. Dan Neely.)

Mercury fungicides are highly toxic and accumulate in animal tissues similar to the way DDT accumulates. Although mercury fungicides may eventually be phased out, they are still available on the market and are the only known fungicides that will control sycamore anthracnose. They should be used with caution. If and when a less toxic material is found that will control the disease, it will replace organic mercury in Survey recommendations for sycamore anthracnose control.

Pollutant Effects on Enzyme Complexes

Most, if not all, of the chemical reactions that occur in the biological world are controlled by enzymes. These enzymes or enzyme complexes enable organisms to synthesize a seemingly endless variety of products that are needed for growth, survival, and adaptation. Protein-like in structure, these compounds act as catalysts and provide the energy needed to carry out a multitude of chemical reactions. For example, oxidation of glucose, a common biological reaction, can be carried out in a test tube, but the process requires high temperatures and is accompanied by an explosive release of heat energy. Living tissues carry out the same reaction under lower temperatures with only a small release of heat, due to the catalytic activity of enzymes.

Chemicals such as pesticides are often toxic to organisms by virtue of their effect on enzyme complexes. One definition refers to pesticides as compounds that derange the normal biochemistry or physiology of organisms to such an extent and for such a period of time that death of the organism results. This definition could also apply to other toxic chemicals such as pollutants. Unfortunately, these materials are not always specific in their toxicity and may cause some adverse effects on desirable plants and animals.

The fact is well known that many species of fish are affected by certain pesticides such as DDT. To see whether pesticides and other pollutants cause damage to fishes by interfering with their enzyme systems, Survey aquatic biologist R. C. Hiltibran has been investigating their effects on three enzyme complexes in the liver of the common bluegill. His findings show that some agents, DDT for example, severely alter one enzyme complex, the succinic oxidase complex, but have relatively little effect on others, like the alpha-ketoglutaric oxidase complex. Many agents, like insecticides, heavy metals, and herbicides, that are extremely toxic to bluegills are able to alter one or more of these enzyme complexes. The effects are severe enough to derange the physiology or biochemistry of the fish. Further, he has been able to demonstrate that in a closely related series of compounds, such as the phenoxy group of herbicides, minor differences in chemical structure can result in different effects on the bluegill liver enzyme systems.

One of the primary metabolic end products of DDT degradation in animals such as fish is DDE. Dr. Hiltibran has found that both these compounds have similar effects on enzyme complexes in bluegill liver, effects which may explain the toxicity of these compounds to fishes.

Further research of this nature may shed more light on how pollutants cause injury in organisms and how this injury can be avoided or reduced.

Hard to Swallow

Introduction of the European house sparrow into the United States began around 1850 in New York and continued into the 1880s in many areas of the country. A number of persons protested at the time but to no avail. Among these was the renowned ornithologist Elliot Coues, who accurately predicted some of the dire consequences of introducing this prolific, highly adaptable bird.

The house sparrow was introduced into Illinois between 1868 and 1874, an unnecessary task since the species was expanding its range rapidly at the time without any outside help. Now, with a one-hundred-year history in Illinois, the influence of the house sparrow is still growing, to the detriment of native bird species. The best-known victim is the bluebird, which was essentially displaced by the sparrows near human residential habitats by 1920.

Less well known are the cliff swallows'

Cliff swallow colony along the Apple River in Jo Davies County. (Photo by J. W. Graber.)

problems with house sparrows. From the time of white settlement in Illinois, cliff swallows adapted their nesting sites to man-made structures. Until recent years many colonies nested on bridges, barns, and other buildings throughout the state. When house sparrows arrived in the state, they began to use nest cavities wherever they could find them and ultimately began to take over cliff swallow nests. House sparrows have all but eliminated barn colonies of the cliff swallow in Illinois. To this point the case is similar to that of the bluebird, but the swallow appears to be in danger of being eliminated from the state because the house sparrow is now competing with the swallow even in its natural nesting areas, namely the cliffs along rivers and streams.

Human activity favors the house sparrow for reasons not fully understood, and the Illinois streams are now so heavily used by humans that the sparrows are thriving. The most numerous nesting species of birds along stretches of the beautiful Fox River now are starlings, house sparrows, and rock doves.

The colonies of cliff swallows along the Fox and Apple rivers make up most of the state's remaining population of this species. To get an accurate picture of the effects of house sparrows on native cliff swallow populations, Survey wildlife specialist R. R. Graber made a survey of these colonies in 1971. He was able to observe nearly all of the colonies and found that each colony showed signs of some invasions by house sparrows.

The case is of interest for two principle reasons. It tells us that we cannot expect to know the full impact of an introduced species even within a century of its introduction. It also shows us that human use of natural areas needs to be monitored carefully for both its direct and indirect effects on the flora and fauna. As human use of an area increases, it may imperil native species by increasing competition from more adaptable introduced species.

Aid to Corn Rootworm Damage Forecasting

Northern and western corn rootworms are economic pests of corn in Illinois. Both the larval and adult stages of these insects feed on the corn plant but most of the damage is caused by the larvae. Adult rootworm beetles lay tiny eggs in the soil during the summer and fall and the larvae that hatch from these eggs the following spring feed on the young corn plant roots.

The potential economic loss to a new corn crop could be estimated in advance by determining the relative abundance of overwintering rootworm eggs. Unfortu-

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nately, this has proven to be a difficult task since the extraction of eggs from the soil is time consuming and expensive. The tiny eggs, less than one twenty-fifth of an inch in length, must be washed through a fine mesh screen, separated by flotation, and counted under a microscope. These laborious procedures have prevented workers from obtaining enough representative samples on a field-wide basis to make a valid estimate of rootworm populations.

In an attempt to improve the sampling technique, Survey entomologist W. L. Howe and technical assistant John Shaw began removing samples from an experimental field using a small bulb setter. By combining ten or more samples, then taking only one or two pints for egg removal, repeatable results were obtained. After making several sampling forays across the same general area of a field of corn stubble, the approximate density of rootworm eggs in the field could be determined with reasonable accuracy. This proved to be far better than the old technique of removing large numbers of soil cores from individual plants and extracting the eggs from each one separately.

According to Dr. Howe, this simple alteration in egg sampling may eventually provide a feasible and practical method for predicting potential larval infestations of the corn rootworms. If a farmer knew that the population of rootworm eggs in his field was below that which causes economic damage, he could very likely eliminate the application of insecticides for rootworm control for that year.

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Bronze Birch Borer

Dieback of the upper branches of white, paper, and yellow birch trees in Illinois is usually the sign that awakens the homeowner to make a close inspection of his tree. Evidence of small ridges and bumps, as well as an occasional D-shaped hole in the bark of the affected branches or trunk is proof that the tree is infested with the bronze birch borer (*Agrilus anoxius*). It is not uncommon for such affected trees to die a few years after dead branches are noted, if no remedial action is taken to prevent borer attacks.

The adult is a small beetle slightly more than three-quarters of an inch in length and very dark bronze in color. The beetles emerge from the trunk or branches of the tree in late May or early June. The exit hole in the bark has a characteristic D or semicircular shape. After mating the female beetle lays her eggs in cracks and crevices of the bark. The eggs hatch in ten to fourteen days and the tiny larvae bore into the bark and begin feeding. The larvae feed in the wood during summer and early fall causing small ridges to appear on the bark surface. The light yellow larvae pass the winter in the wood and in April resume feeding. By early or mid-May the larvae change into a pupal stage and adult beetles appear in late May or early June to complete the life cycle.

In hopes of finding substitute insecticides for DDT to be used to combat attacks of the bronze birch borer, control studies were initiated at the Morton Arboretum in 1969 by Survey entomologists J. E. Appleby, R. Randell, and S. Rachesky. In June of 1969 and 1971 several insecticides were sprayed on trees showing evidence of borer attacks. Adult borers were allowed to emerge in cages in the laboratory in May and June of the following year. The numbers of beetles emerging from branches sprayed with each insecticide were compared and then compared with the numbers emerging from branches of untreated trees. It was found that dimethoate (Cygon) was most effective in protecting trees from attacks of the bronze birch borer when applied in two treatments around June 4 and June 24 (in southern Illinois the best times to spray would be about one week earlier than these dates).

Bronze birch borer adult on birch with D-shaped emergence hole above and to the right. (Photo by Survey photographer Wilmer Zehr.)

Fish-Kills and Sulfides

Survey aquatic biologists have been conducting an extensive water quality monitoring program in the Lake Shelbyville basin since early 1970. It soon became evident that sulfate concentrations in the Kaskaskia River entering the reservoir were considerably higher than in similar portions of the Sangamon, Embarras, and Little Wabash rivers. Survey biologist R. Weldon Larimore predicted that the high concentrations of sulfates in the Kaskaskia might become a problem as they are converted to sulfides by bacteria in the deep, oxygen-deficient waters of Lake Shelbyville. Results of the water quality monitoring program for 1971 proved this prediction to be correct.

Reduction of sulfates and the decomposition of sulfur-bearing organic matter in the deep portions of Lake Shelbyville during summer 1971, produced undesirable concentrations of hydrogen sulfide. This substance is objectionable in trace amounts and toxic at only slightly higher concentrations. Hydrogen sulfide poisoning is believed to be the cause of two fish-kills in Lake Shelbyville during 1971. Discharge of sulfide-bearing water through the dam at Shelbyville resulted in considerable degradation of air quality in the vicinity of the dam. The "rotten eggs" smell of hydrogen sulfide disrupted most water-based recreation in the tail-water area.

An intensive study of the various forms of sulfur present in the Lake Shelbyville basin is being led by Warren U. Brigham, resident biologist at the Survey's Sullivan Laboratory. The effects of sulfides upon the biota of Lake Shelbyville, especially the invertebrates living in the sediments in the deep portions of the lake, will be studied during 1972. Bioassay techniques will be employed to determine the lethal limits and ranges of tolerance to hydrogen sulfide of the principal reservoir species.

The sources and annual cycles of the various forms of sulfur present in the lake basin will also be studied. Two potential sources of sulfates in the Kaskaskia River, industry and oil wells, could be controlled if they were shown to be responsible. Knowledge of the annual cycles of sulfur compounds in the lake could indicate changes in the manner and timing of water discharge through the dam to minimize sulfide pollution in the tail-water area. Preliminary observations during 1971 led to a modification of water discharge which greatly reduced odor problems below the dam. Further investigation may make it possible to regulate the amount and point of outflow through the dam in such a way as to minimize or eliminate conditions in the reservoir favorable to sulfide formation.

Have Venom — Will Bite

The brown recluse spider, *Loxosceles reclusa*, was found to occur in Illinois in 1959 and has since been found in forty-nine counties. In 1971 a single female spider discovered in Vandalia, Illinois, was determined by Survey entomologist John D. Unzicker to be *Loxosceles rufescens,* a close relative of the brown recluse spider, but without a common name.

Both *L. reclusa* and *L. rufescens* are medium-sized spiders with light to dark brown bodies about three-eighths of an inch in length with dark brown legs. Both spiders have the characteristic brown fiddle-shaped marking on the tan-colored head. The characters which distinguish between the two species concern morphological differences requiring high magnification and an expert to discern. Unlike our native black widow spider, these two spiders were accidentally introduced into the United States.

The brown recluse and its relatives in the genus *Loxosceles* have venom which makes their bite serious. The bite from one of these spiders can cause a small to large, slow-healing sore or lesion, and is referred to as a necrotic spider bite. A person may not be aware that he has been bitten, and the wound will go unnoticed until hours later when the bite area becomes swollen and painful. Reactions to the bite vary from minor skin irritation to strong reactions accompanied by rash, fever, abdominal cramps, and nausea. Only rarely does death ensue. In spite of the serious nature of the bite of these spiders the number of confirmed cases is small.

The brown recluse spider and its relatives are commonly found in and around

houses, and this brings them more readily into contact with humans. However, they are shy creatures preferring dark places such as attics, crawl spaces, and other storage areas.

It is strongly recommended that *L. rufescens* be closely monitored in an effort to prevent it and other species of *Loxosceles* spiders from becoming established in Illinois to the same extent as has the brown recluse spider.

The Living Fence, Wildlife, and Corn

Some twenty to twenty-five years ago, considerable emphasis was placed on planting woody cover to increase and improve habitat for pheasants, bobwhites, cottontails, song birds, and other wildlife. One of the foremost woody plantings to dot Illinois lands was multiflora rose. Planted principally as hedges or field borders the quick-growing, white-flowered, thorny *Rosa multiflora,* which was impregnable to livestock, became known as the "living fence."

Within the past decade, bulldozers have been running full-throttle in Illinois's prime agricultural land to clear for crop production those remnant tracts, fencerows, and road rights-of-way still graced by woody vegetation. Now, those hedges of multiflora rose, which loom as bastions for wildlife in the endless Illinois landscape of corn and soybeans, are being threatened by the predatory bulldozer at an alarming rate. The hedges are being removed because people generally believe that they cause a reduction in the yield of crops, particularly corn, planted adjacent to them.

Survey researchers Ronald F. Labisky and William L. Anderson set out to evaluate the effects of multiflora rose hedges on the yields of corn in adjacent fields. They conducted their research at twenty sites along eight hedges in Champaign, Piatt, and Vermilion counties over a five-year period. Their findings indicated clearly that the effect of a hedge on the yield of corn along the hedge *was limited* to the first row of corn immediately adjacent to the hedge. And, in this first row, corn yields were reduced only by about 25 percent. Hence, the impact of multiflora rose hedges on adjacent crop yields is rather insignificant, and does not justify hedge removal for reasons of potential economic gain derived from crop production. One of the greatest attributes of multiflora rose is still its benefit to wildlife!

Upper surface of head region of *Loxosceles rufescens* showing brown violin-shaped marking (most of abdomen and legs cropped from picture). (Photo by Survey photographer Wilmer Zehr.)

Corn Rootworm Resistance

In 1963 at El Paso, Illinois, John Bigger discovered a population of northern corn rootworms highly resistant to the chlorinated hydrocarbon insecticides. Within a couple of years, resistance was present in most of the northern half of Illinois.

Phosphate insecticides, such as diazinon and phorate (Thimet), gradually came into general use and phorate is still enjoying widespread use today. A couple of years ago, carbamate insecticides began to be used for rootworm control. The first was Bux and now Furadan is also available.

With the use of new insecticides came the need to monitor the rootworm population in hopes that we would be able to predict the buildup of resistance to the new insecticides. Since 1964, a program has continued each August in which several members of the extension and pesticide performance and evaluation teams sample many fields where adult rootworm beetles are abundant. These beetles are tested in the laboratory against all of the presently

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used insecticides to determine if they are still susceptible. This has involved thousands of beetles.

Ralph E. Sechriest, Survey entomologist, reports that the level of resistance has not changed for several years. In fact, this last season showed a drop in resistance. This probably was only a result of seasonal differences. So far the Illinois farmers do not need to fear resistance to the phosphate or carbamate insecticides and we will alert them if any problem does develop.

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APRIL 1973 NO. 114

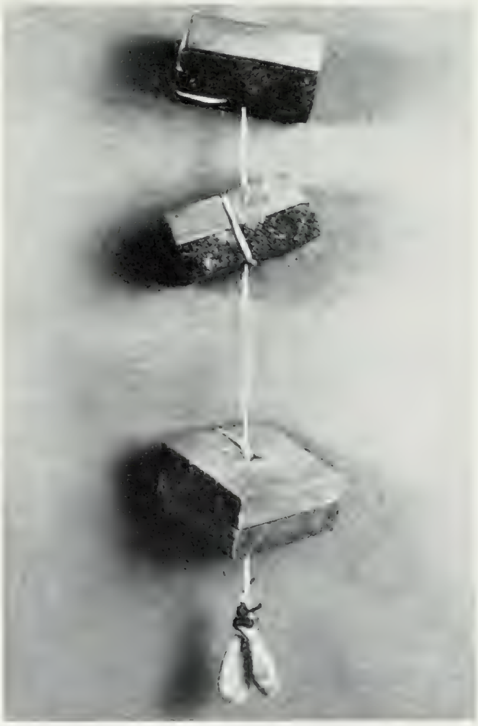
Fungi and Water Quality

The modern era, with all its problems of population pressure, intensive farming, and industrial growth, is plagued by an increasing demand for clean, fresh water. Since the world supply of fresh water is limited, scientists are striving to improve water quality so that maximum use can be made of this limited supply.

Man's activities have generally resulted in pollution of the environment with consequent reduction in the quality of available fresh water. The exceedingly complex nature of aquatic systems, however, has made it difficult to set water quality standards and to determine the overall effects of these activities on our fresh water supply. Most aquatic systems have an intricate, dynamic chemical composition. Changes in this composition are reflected by changes in the delicate balance of flora and fauna that exist in nearly all bodies of water.

Survey scientists have conducted studies over many years on such things as the fishes and mussels of Illinois rivers and streams, and have made highly significant correlations between aquatic pollution and populations of these animals. Very little information is available, however, on aquatic microorganisms, which may be highly sensitive to changes in water quality. For example, we know practically nothing at present about the various species of fungi that are present in fresh water. The possibility that some of these microorganisms may serve as useful indicators of water quality is promising, but as yet unexplored.

One of the main barriers to research on microorganisms in natural fresh water ecosystems is that populations of these minute species are constantly changing from season to season and from year to year. If any meaningful relationship between water quality and microorganisms is to be obtained, it is first necessary to study these organisms in a body of water where conditions can be closely controlled and monitored. With the recent construction of a series of ponds at the Illinois Natural History Survey environmental quality facility at Urbana, such studies are now a possibility.



Wood blocks used as fungal baits for collecting aquatic fungi at various depths in ponds or streams. (Photo by Dr. J. L. Crane.)

To gain some knowledge of the species of fungi present in the new ponds and how the species composition fluctuates seasonally and under altered conditions, Survey mycologist J. L. Crane has initiated a research project using fungal baits composed of wood blocks. These blocks are placed at various depths in one or more of the ponds and are removed after varying lengths of time. By isolating and identifying the fungi present on the blocks, seasonal changes in the aquatic fungal composition can be detected.

For a meaningful correlation of the data obtained on fungal composition with measurements of other water quality criteria, a regular series of determinations will be made on such physical and chemical properties of the ponds as water temperature and dissolved oxygen content. This study is only a first but very promising step in the direction of understanding water quality and its control.

Illinois Prairie Chicken Is Unique

The greater prairie chicken is an integral part of Illinois's heritage. At the time of pioneer farming efforts about 100 years ago, the Illinois prairie was a mecca for millions of prairie chickens. Since then, intensive farming and the pressures of civilization have reduced the numbers of this colorful species to the point where, in the spring of 1971, only about 450 birds were left in the state. These few were divided among nine remnant flocks in seven south central counties. The fact that the species survived at all is a testimonial to the unique capacity of Illinois prairie chickens to persist tenaciously in relatively small areas of suitable habitat.

Fortunately, dedicated conservationists have been able to reverse this trend of decline in a flock near Bogota in Jasper County. Because of the acquisition and careful management of an 862-acre system of nesting sanctuaries, the Bogota prairie chicken flock is increasing — in fact, there have been substantial and consecutive population increases during the past three years. This management effort has expanded to Marion County, near Kinmundy and Farina, where an additional 460 acres have been acquired for nesting sanctuaries. This program offers hope for the preservation of a second flock of prairie chickens in Illinois.

The effort to save our native prairie chicken is the result of the collective cooperation of the Illinois Natural History Survey, the Illinois Department of Conservation, the Prairie Chicken Foundation of Illinois, the Prairie Grouse Committee — Illinois Chapter of the Nature Conservancy, and the Illinois Nature Preserves Commission. The management program for prairie chickens is being constantly monitored through research studies that are being conducted by wildlife scientists from the Survey, who are employed in cooperation with the Illinois Department of Conservation.

Survey wildlife specialists R. L. Westemier and D. R. Vance have observed a remarkable recovery in the Bogota prairie chicken flock, which had declined to a low of about 70 birds in 1968. Three years later, in 1971, they counted 159 cocks in the Bogota flock, an increase of 47 percent over the spring of 1970. For the past three years, the center square mile of the preserve, which contains the Ralph E. Yeatter, Marshall Field III, and Max McGraw sanctuaries (232 acres), has had a density of nearly 100 cocks. Such a density is unparalleled among flocks in other states.

Nesting studies conducted annually at Bogota since 1963 also demonstrate some unique qualities of Illinois prairie chickens. During the past nine years, detailed information has been collected from 293 prairie chicken nests. Although the densities of nests on sanctuaries have averaged 11.2 acres per nest, biologists Westemier and Vance, with their field assistants, found nest densities in certain cover types ranging as high as 1 acre per nest in 1971. Nest success has averaged 67 percent over the nine-year period on the sanctuaries at Bogota. These high nest densities and the high levels of nest success are also unequaled in other states.

Because of the high densities of birds on small tracts, Illinois has a unique opportunity for conducting research on the greater prairie chicken. Biologists are able

Mecoptera of Illinois. Top: male adult scorpion-fly. (Photo by Bob Wright.)
Bottom: male adult snow-sprite. Photo by Survey photographer Wilmer Zehr.)

to gather more data on the nesting ecology of this species in one year than other states have collected during research projects extending for many years. This observation applies to such states as Kansas, Oklahoma, and Nebraska, where up to 40,000 or 50,000 prairie chickens are harvested annually by hunters. Thus, research findings in Illinois on nesting ecology and behavior have important implications for the management of prairie chickens, and probably the closely related sharp-tailed grouse, throughout their range in North America. Also, these studies will help preserve one of our state's most interesting and picturesque native birds.

Mecoptera Insects Studied by Survey

One of the most primitive and interesting of the insect orders that occur in Illinois is the Mecoptera. Species representing four families of this order have been found in the state. Although all known Mecoptera exhibit a complete metamorphosis (pass through a larval, pupal, and adult stage), the four families vary markedly in their morphology and habits.

For the past three years, Survey entomologists D. W. Webb and J. C. Marlin, with the assistance of Norman Penny of the University of Kansas, have conducted a faunal study of these insects in Illinois and surrounding states. Of the sixty-seven North American species of Mecoptera, eighteen occur in Illinois, with an additional thirteen species in the surrounding states.

The most common of the four families, the Panorpidae or scorpion-flies, occur throughout the state inhabiting the dense, moist, herbaceous vegetation along streams and in the bottomlands along rivers. These insects are scavengers, feeding on dying or dead insects. The larvae live in the leaf litter and prey upon the immature stages of other insects. Of the forty North American species, ten have been collected in Illinois, with an additional twelve species occurring just outside the state's borders. The family gets its name from the male's scorpion-like curving of the abdomen, which resembles a scorpion sting but is actually the reproductive terminalia.

The Bittacidae or hanging-flies resemble the crane-flies in appearance and flight and are found in habitats similar to those of the scorpion-flies. These insects are predaceous and hang by their long, stilt-like legs on the underside of vegetation, awaiting any unsuspecting prey. They are found throughout Illinois and six of the eight North American species occur here.

The family Boreidae or snow-sprites is the smallest and most specialized of the Mecoptera. These tiny insects, two to three millimeters in length, live in ground moss, which they apparently use for food. The adults emerge in late December and January and are frequently collected as they move across the snow. Only one of the fifteen North American species has been found in Illinois, in a restricted pocket in the Shawnee Hills.

The rarest and most primitive family of the Mecoptera is the Meropeidae or earwig scorpion-flies. These large, broad-winged insects have been collected primarily at lights and nothing is known of their biology or life cycle. The only species of this family in Illinois has been collected in the

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Pine Hills area in the southern part of the state.

Entomologists of the Faunistic Surveys Section continuously study, identify, and classify the insects of Illinois (and occasionally other states) to add to our knowledge and aid in our understanding of the world in which we live. A manuscript on the Illinois and midwestern species of Mecoptera is now being completed. This paper will describe the midwestern species and discuss their distribution and habitat preference. Keys for identification will also be included. Studies are continuing on the immature stages of these insects and on the effect of certain diseases on their distribution in Illinois.

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Tell-tale Feather Facts

With the advent of spring, northbound flocks of geese again direct the eye from the commonplace. For many observers "to go where the wild geese go" is an ideal. Given the knowledge of the destinations of these free spirits (usually remote, desolate areas of the North with forbidding climates) most would decide that this was one "trip" they could afford to miss. However, for the game biologists whose responsibility it is to safeguard and manage the wild goose populations on their migration routes and wintering grounds, it is important to know where these flocks came from in the first place.

Until now, aluminum leg bands or other types of physical markers have been used to trace migration routes of birds, but the travels of marked birds are often not indicated until months or years later when the sighting of a marked bird is reported or a band is recovered from a dead bird. Trapping and banding operations are expensive and, for every 100 birds banded, the fates of usually less than ten birds are ever known. In the case of Canada geese, the many regional stocks that breed across North America can be recognized by coloration, size, and proportions, but the problem of determining the origins of their look-alike cousins, the blue geese and lesser snow geese, has remained more complex. These geese breed in colonies across the Canadian Arctic and on Wrangel Island off the tip of Siberia and nearly all populations winter either along the Gulf Coast or in some of our western states. The origins of these flocks have had to be inferred from band recoveries of a few.

Recent research has developed a method which provides information making it possible to determine, from geese shot by hunters, the proportion coming from various breeding grounds in the Arctic. After the molt of primary wing feathers on the breeding grounds, minerals that are incorporated during the growth of new feathers provide clues as to where a goose was reared or where a family underwent the molt. The minerals in the feathers are derived from plants the geese eat and water and soil ingested. As no two areas are identical geochemically, the proportion of minerals in the food chain varies and ultimately reflects the local or regional geology.

Chemical analyses of collections of wing feathers of wild geese have enabled two investigators from Urbana, Illinois, Harold C. Hanson, Survey wildlife biologist, and Robert L. Jones, soils mineralogist, University of Illinois College of Agriculture, working

The blue goose. (Photo by George W. Bennett.)

in close collaboration, to establish the chemical bases needed for determining the origin of most blue and snow geese.

In practice, their procedure is as follows: the quantities of 12 minerals in the feathers from geese banded at various colonies are fed into a computer as the bases for comparison; in successive steps by means of a statistical test, the mineral content of feathers of geese of unknown origins are compared with the data on geese of known origins. Printouts of computer calculations indicate the probable chance of each unknown bird having originated from each of the major breeding colonies. The origin of only 5 to 8 percent of the unknown geese from the Midwest and Gulf Coast could not be identified by these procedures. Probably some of the unidentified geese came from unknown colonies, or from colonies where no banding has been carried out.

It is anticipated that one feather plucked from each wing of a living goose may provide sufficient material to establish its home address. It is believed that these findings will usher in a new era of precision in identification of the sources of our waterfowl populations.

Pesticides in Model Ecosystems

Scientists and the public have been greatly concerned with the fate of pesticides and other chemicals in isolated species of birds, mammals, or fish. However, a chemical that is broadcast in the environment may be passed through several plants and animals in a food chain. This may cause the compound to be concentrated as it goes from one organism to another. In more concentrated form the chemical may be dangerous to organisms high in the ecosystem, even to man. Robert L. Metcalf of the University of Illinois at Urbana-Champaign has developed a model ecosystem as a laboratory tool to be used in determining the ability of chemicals to concentrate in living systems. Dr. Metcalf holds a complimentary appointment in the Illinois Natural History Survey.

The Survey has recently established a service unit for monitoring the fate and effect of pesticides and other chemicals in model laboratory ecosystems. This unit, under the direction of Survey entomologist Gary M. Booth, uses the Metcalf model ecosystem in modified form. Organisms included in the Metcalf model are sorghum, salt marsh caterpillars, algae, zooplankton, snails, mosquito larvae, and mosquito-eating fish. To this have been added freshwater clams and aquatic vascular plants.

Several different types of chemicals have already been investigated. The first of these was DDT which is now found in every kind of environment in the world. In the model ecosystem we find that DDT is magnified or concentrated through the food chains duplicating what has happened in the outdoor environment. Therefore, DDT serves as a base line for comparison with other test chemicals.

One herbicide, three of the nonpersistent-type insecticides, and an industrial plasticiser have been programmed through the model ecosystem in the past few months. Results indicate that the plasticiser behaves similar to DDT in the model ecosystem, but the herbicide and the three nonpersistent insecticides do not become concentrated. Some 14 radiolabeled pesticides and industrial pollutants will be investigated during the next two months. An interesting finding is that freshwater snails seem to be better animals for monitoring chemicals in the models than freshwater clams.

This service unit has been initiated with support from the State of Illinois Environmental Institute. Several industries have already contributed chemicals to the project because of the importance of obtaining this type of information.

Our society can no longer afford to wait several decades for the environmental consequences of the spread of chemical pollutants. Recent USDA regulations emphasize this by requesting detailed environmental information as a registration requirement for pesticides. The Survey pesticide residue team using model ecosystem screening methods should help in providing the needed data.

Cicada Spectacular

One of the truly spectacular events in the insect world is the emergence of the periodic cicadas. The cicadas were held in

An adult cicada. (Photo by Survey photographer Wilmer Zehr.)

awe by the Indians and were among the first insects reported upon by the English explorers at Cape Cod in 1634.

The uniqueness of the periodic cicadas is that they emerge from their subterranean burrows all at once, after 13 or 17 years of life as underground nymphs. The males call in unison to attract the females and the noise from the hundreds of thousands of male singers drowns out normal conversation of nearby human observers.

After years of intensive study, it is known that there are 30 broods of 13- and 17-year cicadas. Broods I to XVII emerge every 17 years, and occur mostly in the northern states of eastern United States. Broods XVIII to XXX occur mostly in the southern states. Illinois is a long state embracing both northern and southern zones and both types of periodic cicada are native to our area. A total of six species are now recognized, three species of 17-year cicadas and three species of 13-year cicadas.

Brood XII, a 17-year cicada, is scheduled to appear in Jo Daviess County and Brood XIX, a 13-year cicada, is scheduled to appear in central Illinois from May through June, 1972. The common dog-day cicada appears regularly every year, mostly in July and August.

This spring, Survey entomologists led by L. J. Stannard will monitor the emergence of these cicadas and plot their distribution. Due to human occupation and to the clearing of forests our broods have dwindled in range and this reduction will be one of the points to be investigated. Observations, specimens, and notes by citizens in Illinois will be welcomed by the Natural History Survey.

The next broods expected in Illinois will appear as follows: Brood XIII (17-year) in 1973 in northern Illinois, Brood XIV (17-year) in 1974 in extreme eastern Illinois, Brood XXIII (13-year) in 1976 in southern Illinois, Brood XXIV (13-year) in 1977 in Alexander County, and Brood III (17-year) in 1980 in central and western Illinois.

Computerized Caterpillars

Regulating insect populations for crop protection requires the cooperation of many researchers. Some of the workers directly associated with insect problems are the applied entomologists and the insect taxonomists. The former are frequently dependent on the identification services of the taxonomists when unusual insects appear on the prize shrubs of a homeowner and in field crops. Determining the insect's name is the first step in initiating a practical insect control program that will minimize environmental damage. The name of an insect is the *key* to finding published information on the species for assessment of its potential as a pest warranting actual control. One way to help identify a plant-feeding insect is through its host-plant association. The idea is to eliminate other known species of insects that do not feed on the plant or crop in question. This approach is feasible if updated host indexes are available for a given insect group.

One important group, the family Noctuidae (Lepidoptera), includes approximately 2,000 species of moths in the United States and Canada. The caterpillars of this

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group commonly are called cutworms and armyworms, some of which are serious agricultural pests and other potential pests; yet others are beneficial for the biological control of weeds. Published host records are known for the noctuid caterpillars of about 900 species in America north of Mexico. However, the information on host relationships exists largely in scattered publications and the unpublished records kept by various research institutions. As a result, it is difficult for researchers to know all the host plants of a given caterpillar, and there is no complete listing that covers North America for the described caterpillars that are known to feed on individual host species.

Survey entomologist George L. Godfrey is compiling a catalogue of the hosts of the Noctuidae from America north of Mexico to fill this void. The catalogue will include a caterpillar-to-host index, host-to-caterpillar index, and a bibliography pertaining to the hosts and life histories of the cutworms and armyworms. The most recent bibliography for the discipline was published in 1889. The updated catalogue will be used by agricultural workers to help identify immature noctuids. It will also aid workers screening insect species that can be used as biological control agents for specific noxious weeds. In addition, applied entomologists readily can obtain references pertaining to the basic life histories of specific species.

A computer program was developed by Mrs. Ilona Klein, Survey computer programmer, to handle the large quantity of information that is being assembled. The computerization of the data greatly facilitates the cross-indexing of host relationships and updating the entire catalogue. To date partial host screening is completed for 738 species of noctuid caterpillars. Total listings of the indexes compiled from the screening program are available to interested persons.

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Insect Feeding Stimuli Studied

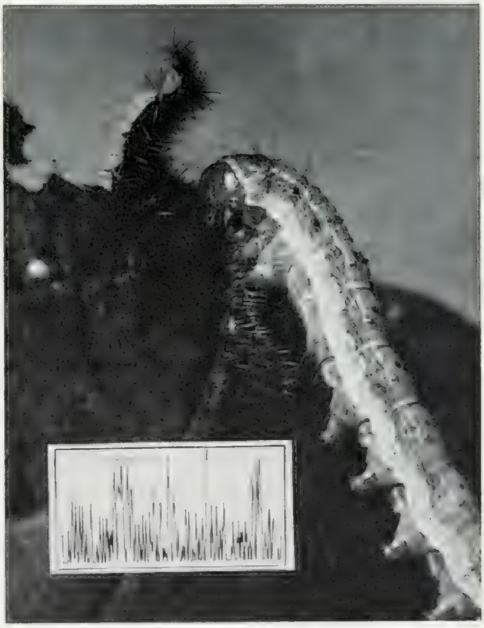
The damage caused by insects to a crop is a result of the combined efforts of millions of these creatures to ingest the largest possible amount of food in the least possible time. How they accomplish this is a complex process in which the plant plays a very central role.

The plant emits certain chemical stimuli that are detected by the insect and incite him to make the first bite. This first bite allows the insect to "feel the taste" of the food and tells him whether the food is acceptable or not for continued feeding. If continued feeding occurs, the plant must provide all the nutrients necessary for normal growth and development of the insect, since the plant is generally their sole source of nurture.

During this chain of events there is a constant interaction of plant and insect, with each step of the process being mediated by one or more chemical components of the plant. If we can learn the mechanisms underlying these interactions, we may be able to manipulate the plant in such a way that it no longer produces the proper stimuli for some critical phase of the feeding process, thus breaking the chain of events and preventing the buildup of damaging pest populations.

Studies of this nature are being conducted by Survey entomologist Marcos Kogan, who is attempting to analyze specific stimuli derived from soybean plants and their effect on insect feeding on soybeans. In the course of these studies a sensitive bioassay was developed to investigate the early phases of the feeding process, such as the stimuli that trigger the first bite. This bioassay uses a delicate electronic device, a displacement sensor, which is very similar to a cartridge of a stereo phonograph. The sensor detects the vibrations of the leaf whenever the insect makes a bite.

These vibrations are amplified and displayed on a chart using an event recorder as shown in the accompanying photograph. Moving the chart at high speed, individual bites can be detected as a sawtoothed sequence of spikes. Different insect species have different feeding patterns. The pattern illustrated represents a recording obtained with the corn earworm, *Heliothia zea,* feeding on a soybean leaf. The chart



Feeding frequency of the corn earworm on a soybean leaf as detected by a displacement sensor. (Photo by Survey photographer Wilmer Zehr.)

was moving at 12 inches per minute, thus the earworm feeds at a speed of three bites per second.

Changes in the chemical characteristics of the plant can reduce this feeding activity or delay its onset. If the biting activity is reduced to a certain level, the animal is no longer able to secure enough nourishment for normal development. Resistant plants cause changes of this sort and the characteristics of certain resistant lines of soybeans are being studied as part of a breeding program for soybean insect resistance.

Gladiolus Viruses: Good or Bad?

Many flowering ornamental plants command premium prices because of their "broken" or variegated color patterns. In most cases, color breaking in flowers is an inherited genetic character. In some instances, however, color breaking is caused by the action of a virus.

Before the discovery of viruses the condition known as tulip break, in which there is a break in the flower color due to virus action, was considered a novelty and bulbs from infected plants sold at premium prices. Now that we realize a virus is involved, we avoid the "broken" flowers rather than seek them out.

In gladiolus, a flower break was reported about thirty years ago. Investigation proved this to be caused by the cucumber mosaic virus, which infects many different species of plants. In glads this virus causes the so-called "white break" disease that shows up as various color patterns in the florets of varieties other than those with white or yellow flowers. Many people find the resulting flower patterns attractive but the disease, which was not recognized until relatively recently, is now considered an important disease of gladiolus. The flowers are often severely distorted after the plant has been infected for several generations.

In recent years, two additional flower novelties have been found in glads. These are the conditions referred to as "protrusions" and "club head." At first, Survey plant pathologists J. L. Forsberg and Walter Hartstirn thought these odd formations might be caused by insects, but closer inspection indicated this was not the case. Laboratory studies reduced the possible explanations to an inherited factor or a virus problem. The pattern of symptom occurrence led the researchers to believe that both conditions were due to virus infections.

These conditions occur at such low rates in the field that they are insignificant. As specialists on the occurrence of diseases, however, doctors Forsberg and Hartstirn realized that white break, now an important virus disease of gladiolus, started in this same manner. Therefore they felt these two new conditions were worthy of investigation. In addition, an amateur hybridizer of glads had recently observed these conditions and suggested that they may be valuable as novelties. The expression of such thinking brought back memories of the tulip break situation of the past and emphasized the importance of trying to establish the cause of the conditions. It was just possible that virus diseases were again being propagated unknowingly.

Investigations thus far have not established the causes of protrusions or club head, since efforts to infect healthy glads have not been successful. Additional experiments are in progress, however, and others are planned to find the cause of the conditions. If the problems are indeed viral in nature, it is hoped that early recognition may prevent them from becoming important problems. Glads are now recognized as important carriers of viruses that affect many crops and flowers. And it should be worthwhile to prevent them from carrying any more.

Stress and Tree Diseases

Certain disease organisms, particularly those causing leaf spots and blights, may attack trees in a vigorous growing condition. Such diseases can often be prevented through application of fungicides or antibiotics. Many of the disease organisms associated with severe tree problems such as stem cankers, diebacks, and root rots, however, only attack trees that are under some type of stress. When a tree is weakened by drought, flooding, freezing, defoliation, or some other factor to the point where it becomes susceptible to attack by a disease

Formation of a fungus canker on a stem of European white birch weakened by defoliation. (Photo by D. F. Schoeneweiss.)

organism, infection usually occurs. When a stem or root disease appears, it is too late to use preventive measures and chemical treatments rarely, if ever, affect any cure.

The importance of environmental stresses in the occurrence of tree diseases is well recognized. Very little is known, however, concerning how various types of stress effect disease susceptibility and how these stresses can be avoided. How long and how severe must a drought be before a given tree species becomes susceptible to a certain disease? What weather conditions will result in freeze damage or weakening in different trees? How should trees be treated during transplanting or during a prolonged drought to prevent them from becoming diseased? These and many other questions remain unanswered due to a lack of basic information on disease susceptibility in plants.

Scientists at the Survey are developing and refining methods and techniques for studying environmental stresses and their influence on disease susceptibility in trees and other woody plants. Recently technical assistant Cary Crist, working in cooperation with plant pathologist D. F. Schoeneweiss, has found that the susceptibility of European white birch, *Betula alba,* to a common canker disease caused by the fungus *Botryosphaeria ribis,* is dramatically influenced by certain environmental stresses. Although this fungus will not infect vigorous birch seedlings, if these same seedlings are defoliated periodically or placed under drought conditions, infection occurs and cankers are formed on the stems. Freezing due to a rapid drop in temperature, which causes many tree species to become susceptible to infection, appears to have little effect on white birch. Results such as these may eventually lead to better recommendations for disease control on this valuable ornamental species.

The ability to manipulate disease susceptibility under controlled conditions should prove to be an extremely valuable tool in improving our understanding of plant diseases. If a plant can be made resistant or susceptible to a disease organism by manipulating the environment in the laboratory, it may be possible to investigate the basic mechanisms of disease susceptibility in plant tissues. This would be a big breakthrough in the field of plant pathology and could lead to some vast improvements in disease control.

Where Bass Grow Best

Many factors which influence fish growth are not known, and it is a time-honored concept that best growth occurs when the population is least dense. But this may not always be true for certain species when in association with certain other species. Survey biologists Homer Buck, Richard Bauer and Russell Rose conducted some preliminary experiments to test these ideas.

To learn more about growth in largemouth bass it was necessary to train bass to accept pelleted feed, rather than live food, which bass normally require. The experiments were of two basic types: (1) bass were mixed in direct association with other fish species, and (2) bass received water transferred from aquaria containing other fish species. The small fish (2–4 inches) were fed measured rations of Purina trout chow based on percentages of body weights. All populations were sampled and new rations determined every fourteen days in some tests, and every twenty-

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one days in others. All tests were replicated twice.

In the first experiment small bass were mixed with each of four species (bluegills, channel catfish, golden shiners, and Java tilapia), and bass were maintained alone. The tests ran for 105 days, and then were terminated. Populations of bass mixed with bluegills, with catfish, and with tilapia each outweighed those populations of bass maintained alone, while weights of bass alone were approximately equal to weights of those mixed with shiners.

In a second test we hoped to determine whether the influence of one species upon the other was through direct physical association, through some factor imparted to the water, or whether one species might simply be "hogging" the food of another. In this instance we maintained bass populations alone and periodically replaced three-fourths of the water with water drawn from aquaria containing either bluegills, channel catfish, tilapia, or tadpoles. The study ran for 110 days. At the conclusion, bass which had received water conditioned by bluegills were larger than those bass which had received aged pond water or water from the other three groups of organisms.

In a third experiment we maintained bass alone and bluegills alone, and mixed bass with bluegills, with bluegills and channel catfish, and with bluegills, channel catfish and tilapia. In this test bass mixed with bluegills made the best growth, followed closely by bass mixed with bluegills, tilapia, and catfish. In all cases bass growth in mixed populations exceeded that made by bass alone. We can point out two additional items of special interest: (1) bluegills made the fastest growth when maintained alone, and gains by bluegills were limited in direct proportion to total fish density, regardless of the species involved; and (2) the addition of tilapia to the bass-bluegill-catfish combination caused growth of bass to exceed that of bass mixed only with bluegills and catfish even though it greatly increased the total population density.

In the fourth and final test we considered again the influence on bass growth of water transferred from aquaria containing other species. The study ran for 105 days. Best early growth was made by bass receiving "bluegill water," but best final growth was by bass receiving "tilapia water," and both exceeded growth of bass receiving water from aquaria containing no fish.

The results of these studies suggest the intriguing possibility that bass growth may be enhanced by the presence of bluegills above and beyond the bluegill's contribution to the diet of the bass.

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JULY 1972, NO. 117

Gray Squirrel Reproduction

A popular Illinois small game animal familiar to most citizens of the state is the gray squirrel. Survey wildlife specialist Charles M. Nixon has been studying the reproduction of female gray squirrels in Illinois in order to better understand population fluctuations and suggest management practices.

Female gray squirrels are considered to be diestrus, that is, having two breeding periods per year, one from January to March and another from June to August. During a year more than 95 percent of the adult (over 13 months in age), 50–60 percent of the yearling (10–12 months), and 5 percent of the subadult (less than 10 months) females may be expected to breed and rear young. However, during either of the two breeding periods only about 60 percent of the available breeders actually undergo estrus.

Both age of female and season of breeding affect the fecundity of gray squirrels. Yearling or subadult females produce on an average fewer young than do adult females, and summer-breeding females average more young than winter-breeding.

Tagging of nestlings has shown that adequate nutrition is particularly important during the period between weaning and puberty (3 to 10 months in age). This is also the period during which most dispersal and mortality of squirrels of both sexes occur.

The quantity and quality of the food supply available to female gray squirrels also affect their fecundity. Over an eight-year period of study it was shown that breeding activity may be reduced just prior

A gray squirrel from Illinois. (Photograph by W. E. Clark, former Survey photographer.)

to and after a food shortage. During a year with a high population density and a poor mast (dry fruit of trees, especially nuts) crop, less than 5 percent of the adult breeders had two litters.

In contrast to most small game animals, gray squirrel reproduction is relatively low, averaging only two to four young per breeder per year. Survival rates are high, however, averaging about 30 percent for first-year squirrels and 50 percent each year following the first. Most gray squirrel populations experience a recurring cycle of mast abundance and scarcity. Periods of mast abundance are commonly followed by high fecundity and higher than normal survival of juveniles and adults. A mast failure, operating on a crowded, largely young population of squirrels, produces a high rate of dispersal and mortality followed by a lowered fecundity.

The Mighty Midge

The increasing public interest in pollution, particularly in the aquatic environment, has increased the demands on taxonomists for the identification of aquatic insects. One of the most abundant groups of aquatic insects in numbers and species is the Chironomidae or nonbiting midges. As adults, these mosquito-like insects do not feed and are of little interest, except that they are attracted to lights and during peak periods of emergence can be a nuisance. For more than 90 percent of their life span these insects live as worm-like larvae in the bottom sediments of lakes, ponds, and streams, or attached to aquatic plants and algae. To the aquatic biologist or pollution ecologist, this larval stage is of prime interest, providing an index of pollution by noting the presence or absence of tolerant or nontolerant species.

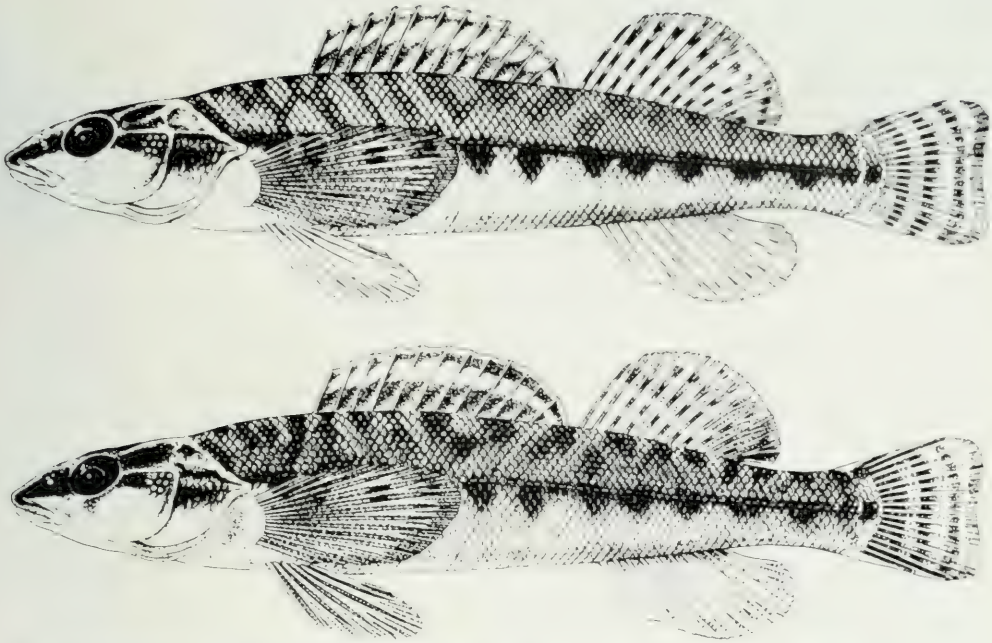
The life cycle of the nonbiting midge is relatively simple with the eggs laid in a gelatinous mass, attached to surface debris or simply settling on the bottom sediments. The larvae undergo four molts, allowing them to increase in size. Larvae feed primarily on suspended organic matter or algae in the water with certain groups being predacious on smaller aquatic worms or other insect larvae. The larvae pupate in the bottom sediment with the pupa wriggling to the surface similar to a mosquito pupa. Suspended by surface tension the pupa splits its skin down the middle of its back and the adult emerges. The newly emerged adults fly to shore and form large swarms or aggregations of males. On warm summer evenings these swarms, comprised of countless males, may take on the appearance of a cloud of smoke. Females are attracted to these swarms and following mating they release their eggs over the water to begin the cycle again.

The Chironomidae is one of the largest families of Diptera or true flies in North America, with over 140 different kinds or species recorded in Illinois. Most aquatic biologists or ecologists are unfamiliar with the adults and are reluctant to attempt to determine species on the basis of larval characters due to the paucity of information on the larval stages of most species. In an effort to provide field biologists with adequate means of identifying larval stages Survey entomologist D. W. Webb is presently engaged in a study of the midges of Illinois to determine the species composition and to associate the larval, pupal, and adult stages.

To insure the proper identification of a larval form, specimens have to be reared through to the adult stage, which possesses considerably more morphological characteristics by which to recognize the species. Larvae are reared individually in vials containing a small amount of water and capped with cotton. As one stage passes to the next and finally to the adult, the discarded skins of the larva and pupa, as well as the emerged adult, are retained in the vials. These discarded skins still retain the morphological characteristics necessary for the identification of these stages. The emerged adult can then be identified and the larval and pupal stages associated. Descriptions, illustrations, and keys are being prepared from this material which will eventually allow the aquatic biologist to make his own determinations.

Slenderhead Darter Data

For several years Survey scientists have conducted detailed life history studies on



The slenderhead darter — female above and male below. (Drawings by Mrs. Alice Ann Prickett.)

Illinois plants and animals in the belief than an understanding of the relationship between an organism and its environment requires knowledge of ecological requirements of that organism throughout its entire life. A recently published paper in the *Natural History Survey Biological Notes* series is entitled "The life history of the slenderhead darter, *Percina phoxocephala*, in the Embarras River, Illinois." This study, by Survey ichthyologists L. M. Page and P. W. Smith, summarizes information gathered during a two-year period on habitat, behavior, reproduction, development, growth, longevity, population density, associated species, migration, food habits, and such interactions with other animals as competition, predation, parasitism, and hybridization.

The slenderhead darter was first found in central Illinois and formally described and named by Edward M. Nelson in 1876 in the first volume of the Survey's bulletin series. The species is widely distributed and still rather common in this state, but elsewhere it is sporadic in distribution. It is cited in the Department of Interior's *Redbook of Rare and Endangered Fish and Wildlife of the United States* as a species whose status is undetermined. The study of its life history by Page and Smith provides detailed information on its ecological requirements and also contributes to our understanding of the total environment.

The authors found that the reason for the species' success in many Illinois streams was the presence of relatively undisturbed gravel raceways. The greatest threat to the species is destruction of the raceway habitat by dam construction, but dredging of channels and deterioration of water quality would also adversely affect the species.

Copies of this 14-page life history study are available upon request to the Illinois Natural History Survey.

Arborvitae Leaf Miner

Arborvitae are among the most popular ornamental trees in Illinois. They are used as foundation plantings, along driveways and walks, and to make interesting evergreen groupings in parks and public places. Several insect pests affect the health and appearance of arborvitae.

The arborvitae leaf miner (*Argyresthia thuiella*), the caterpillar or larvae of a

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small moth, is one of several pests of this common ornamental plant. The leaf miner causes the foliage to die back one to three inches and heavily infested trees have a poor appearance from May through August because of the abundance of brown foliage. The caterpillars are tiny and tunnel (mine) inside of the leaves. They overwinter as immature larvae inside of the leaf mine. In April the larvae resume feeding until May when they transform into the inactive pupal stage within the leaf mine. Adult moths emerge in June and, after mating, eggs are deposited on the foliage. Young larvae hatch from the eggs and bore into the leaves. The terminal leaves become yellowed and later in the summer light brown or blanched in appearance. Injury is often most serious where plants are growing in partial shade.

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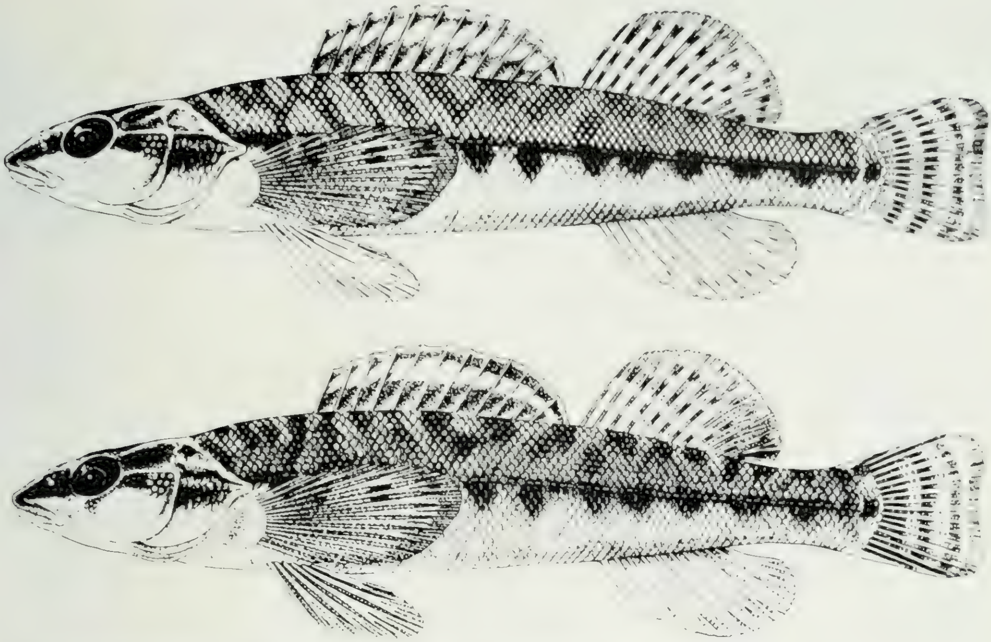

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AUGUST 1972 NO. 118

Problems in Trapping Bass

Traps made of round hoops covered with cotton or nylon mesh netting are widely used in commercial fishing. They are also used in biological work for catching needed fish specimens and, to some extent, for tracing the rise and fall in fish populations.

In a recent study of trapping data collected over a long period of years at Lake Glendale and Canton Lake in Illinois, Survey aquatic biologist D. F. Hansen has found that this method of fishing does not provide the biologist with reliable information on population trends. For example, at Lake Glendale it was found that catches of bass vary greatly with the time of year trapping is done. All sizes of bass, from six inches to twenty inches, were much more susceptible to capture in early spring, especially March, than in late spring or summer.

While the reason for the decline in trap catches in the summer is uncertain, this decline is correlated with clearing of the water, providing greater visibility of the net opening for fish trying to avoid the traps and those trying to escape after capture. The decline is also correlated with a tendency of bass to make greater use of deep water in the summer.

At Lake Springfield, in a direct comparison of traps made of one by one-inch netting and two and one half by two and one half-inch netting, the coarse nets were decidedly better for catching three-pound and larger bass. In Illinois and many other states, biologists have often depended entirely on the fine mesh nets for all their fish sampling.

Another serious failure of the trap method in bass sampling occurred at Lake Glendale. Here traps were fished nearly every spring beginning one year after stocking in 1941 and continuing until 1964. Failure of the traps to correctly show a population trend began in March 1946, when for the first time hardly any bass were caught in the traps. Over the next eighteen years, catches of bass over thirteen inches long were extremely scarce and smaller bass were always scarcer than they had been from 1942 through 1945.

The fact that complete records of fish

Trapping fish at Lake Glendale for biological studies. (Photo by D. F. Hansen.)

caught by sport fishermen at Lake Glendale showed that bass fishing was much better from 1948 to 1958 than from 1942 to 1946 showed that trap catches had indicated a downward trend in population which obviously had not occurred.

At Canton Lake, which was completed the same year as Lake Glendale and where traps were also fished each spring from 1941 to 1964, the trend in trap captures of bass over the years was very much the same as described for Lake Glendale. The reason for the decline in trap captures of bass in both lakes may have emerged in Dr. Hansen's discussions with some of the more successful Lake Canton sportfishermen. They told how, up to 1945, bass fifteen to sixteen inches long had been easy to catch in shallow water. In 1945, when the prevailing size of large bass ran seventeen to eighteen inches, they became very hard to catch in shallow water but could still be caught in deep water. In the late 1940s, individual fishermen caught as many as fifty bass a summer, averaging two to three pounds apiece, by fishing deep running baits close to the bottom.

The reason for the apparent mass movement of bass to open water in 1945 and not earlier is still unknown. Some changes in the lakes, perhaps in distribution of food as a result of aging, is one possibility.

Clean Milk Plus Dairy Insect Control

The Illinois Natural History Survey has long recognized the potential hazards of controlling insects with chlorinated hydrocarbon insecticides on dairy farms. To avoid contaminating milk with insecticide residues, extension entomologists working jointly with the Survey and the University of Illinois have attempted to phase out the use of these insecticides in the state.

Since 1951, we have advised against the use of DDT and, since 1965, against the use of aldrin, dieldrin, chlordane, heptachlor, and lindane on dairy farms. In 1970, the use of chlorinated hydrocarbon insecticides was no longer suggested for farms in Illinois, and in September 1971 it became illegal in Illinois for dairymen to apply or to store on their farms the above-mentioned insecticides.

The attitude of the Survey and the University has been that the dairyman's first responsibility is to produce milk free of harmful residues and only second to control his insect problems. To aid the dairyman in controlling insects, suggestions based on research conducted at these two institutions were presented in University of Illinois Circulars 898 (Insecticide Guide for Livestock) and 899 (Insecticide Guide for Field Crops). The suggestions made in these circulars allow dairymen to control insects and still produce milk free of insecticide residues.

The vast majority of Illinois dairymen have followed these suggestions, even though alternative insecticides and controls were usually more expensive, less effective, and more hazardous to handle than the chlorinated hydrocarbons. These dairymen certainly deserve a pat on the back from all the citizens of Illinois and other states where Illinois milk is consumed.

The problem of insecticide residues in milk has not been completely eliminated as yet, however, since a few dairymen have continued to use chlorinated hydrocarbons for insect control. Although residues have been found in less than one percent of the more than 12,000 dairy herds in Illinois, Survey scientists feel that this number should be reduced to zero.

The main difficulty has been the occurrence of dieldrin residues in milk as a result of the continued use of aldrin as a soil insecticide on corn. Aldrin converts to dieldrin in the soil. To attempt to determine the source of the dieldrin contamination, Survey extension entomologist Steve Moore conducted a study in 1971 of twelve dairy farms which had dieldrin residues in milk. These were Grade B dairy herds located in an intensive grain-producing area and did not represent a cross section of Illinois dairy herds. County extension advisers Robert Lane and Benjamin Greiner and area extension adviser Stanley Smith lent assistance in circulating questionnaires to the cooperating farmers and in obtaining milk samples, which were analyzed for insecticide content by Survey entomologist W. N. Bruce.

As a result of this study, the scientists

concluded that the chances of illegal dieldrin milk residues occurring are greatest on dairy farms having a history of aldrin soil treatments within the last six or seven years. Hay and oat straw supply significant amounts of dieldrin to dairy cattle, whereas corn silage, commercial feed concentrates, and water are usually not important sources of dieldrin contamination. Roasted soybeans, a relatively new feed for dairy cattle, could be an important source of dieldrin contamination on some farms.

According to Dr. Moore, dairy farmers can avoid producing milk with illegal pesticide residues if they follow certain precautions. Chlorinated hydrocarbons should not be applied or stored on dairy farms and cattle should not be pastured on land treated with aldrin or heptachlor within the past six years. Corn may be grown on land treated with these insecticides but cattle should not be grazed on the corn stubble. Bedding cattle with hay or soybean straw from fields treated with aldrin or heptachlor in the past six years should be avoided. Corn or oats purchased as grain should be safe for dairy cattle feed, but roasted soybeans, hay, haylage, or oat straw could be contaminated if grown on land with a history of aldrin or heptachlor usage, and should be avoided.

Close attention to these precautions should eliminate most problems with insecticide residues in dairy herds.

Freeze Injury in Midsummer?

The winter of 1971–72 was relatively mild in Illinois, judging from the number of degree days and other methods of estimating winter severity. Why then, has so much freezing damage appeared on trees and shrubs this spring and summer? A large percentage of the more than 500 woody plant specimens received by the Survey's Botany and Plant Pathology Section up to the end of July showed symptoms of freeze injury.

The amount of freeze damage showing up this year is not surprising, however, if one has some understanding of what conditions result in freezing injury to woody plants. It makes little difference how low the temperature gets, since many woody plants can survive temperatures of minus forty degrees Fahrenheit or more without appreciable damage, provided the temperature drop is gradual over a long period of time. What usually causes freeze injury is a rapid and extensive drop in temperature following a prolonged warm period, sometime between early fall and late spring. A closer examination of weather conditions during the past winter should shed some light on the appearance of freeze injury this summer.

The fall of 1971 was unusually mild with few frosts until late in the season. If you have a good memory, you may recall the sudden hard frost in late fall that froze the leaves on sweetgum, oak, and many other woody plants. Results of this frost can be seen this year in the absence of blossoms on forsythia, peach trees, rhododendrons, and other spring flowering plants due to killing of buds. In addition to this injury, several hard freezes, in some cases to well below zero, occurred following prolonged warm periods during the winter. In some areas, a hard frost occurred well after new growth had emerged in the spring.

The combined effects of these conditions have shown up as bud kill, branch dieback, and sudden wilting and drying of branches or entire portions of trees and shrubs. Such injury is due to killing of stem tissues by freezing and may be accompanied by girdling of stems by disease organisms that attack tissues weakened but not killed by freezing.

A subtle aspect of freeze injury that causes skepticism whenever specimens are so diagnosed during the summer is the fact that shoots of woody plants may continue to wilt and die throughout the season, as a result of freezing injury that occurred the previous winter. Since water will continue to move for a period of time through nonliving tissues of stems girdled by freezing, such stems may put out new shoots which appear quite normal, until they suddenly wilt and die almost overnight. Some shoots may appear healthy until July or August before dying. In other cases, stems that are injured but not girdled may be attacked by disease organisms, which eventually cause girdling and death later in the

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growing season. During investigations on stress and disease susceptibility in woody plants, Survey plant pathologist D. F. Schoeneweiss has found that woody stem tissues weakened by freezing often become susceptible to infection by canker fungi that do not attack unfrozen stems.

Some freeze damage to woody plants appears every year in Illinois but the species affected and the severity of damage are variable, depending upon the time of year and the conditions under which freezing occurs. This year white pines were badly damaged in some areas, which is quite unusual. Other plants affected were some varieties of juniper, arbor-vitea and yew, weigela, red barberry, cotoneaster, euonymus, and certain other species in local areas.

It is doubtful that freeze damage can be completely prevented by any particular treatment. Species repeatedly injured by freezing should be planted in sheltered locations, and only very hardy species should be planted in low, moist sites where freezing is more severe. Plants that show freezing damage at the base of stems near the ground may be mulched in the fall to protect sensitive stem tissues. Early fall fertilization may result in prolonged growth and delayed cold hardening, which can increase chances of freezing injury. Other than these measures, little can be done to prevent freeze injury except to hope for less severe weather fluctuations in the winter.

Freeze-damaged stems should be pruned out since disease organisms may attack weakened tissues and cause further damage. Injured plants should be watered and fertilized in late fall or early spring to restore vigorous growth.

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SEPTEMBER 1972, NO. 119

Pheasants: Age and Eggs

Bit by bit, evidence is accumulating that adult hens (those that have experienced at least one breeding season) constitute the "backbone" of wild populations of pheasants in Illinois. The latest findings relating to this subject can be found in a recent Survey pamphlet entitled *Dynamics of Condition Parameters and Organ Measurements in Pheasants,* authored by Survey wildlife biologist William L. Anderson. Data strongly suggest that adult hens are in better physical condition than juvenile hens during much of the year; more specifically, mean weights of the entire bird, of muscular tissues, and of fat deposits are greater among adult hens than among juvenile hens during the fall, winter, and spring months. Thus, adult hens might be expected to enjoy higher rates of survival during winter and higher rates of reproductive success during spring than juvenile hens.

Anderson gives support to his conclusions by demonstrating that adult hens become sexually active at an earlier date than juvenile hens and, for any given date during the breeding period, adults will have produced more eggs than juveniles. In an earlier study Survey wildlife biologist Ronald F. Labisky and endocrine physiologist Gary L. Jackson found that in captive pheasants two-year-old hens laid a greater number and a greater weight of eggs seasonally than did either one-year-old or three-year-old hens (*Natural History Survey Reports,* June 1970). These workers concluded that two-year-old hens may contribute more

Pheasant eggs hatching. (Photograph by Survey photographer Wilmer Zehr.)

young to pheasant populations annually than their relative numbers in the breeding flock would indicate. In yet another study involving marked birds in the Sibley study area, former Survey wildlife biologist Stanley L. Etter found that adult hens survived in greater proportionate numbers than juvenile hens during the fall and winter months.

Thus, as remarkable as it seems, these studies — involving captive birds, wild birds, population dynamics, and physiology — are almost in total agreement in indicating that adult hens are probably indispensable in maintaining huntable populations of pheasants in Illinois.

Carlinville Revisited

Few areas offer a better opportunity to study the general effects of our intensified agricultural economy upon the fauna of a large group of land insects than the Carlinville, Illinois, area and its native bee fauna. Mr. Charles Robertson collected bees intensively in the vicinity of Carlinville about 70 years ago. He collected 298 species of native bees and recorded several thousand detailed notes on their flower visits and preferences. Robertson's entire collection of bees and all of his notes are now part of the Survey's large holdings of Illinois insects.

During the past two years Survey entomologists J. C. Marlin and W. E. LaBerge have been restudying the bee fauna of the Carlinville area. Over 11,000 specimens have been collected to date. These were taken from flowers of about 20 plants chosen in order to maximize the number of species of bees collected throughout the season. Plants such as *Salix interior* (a willow), *Aster pilosus* (a small white aster), *Helianthus grosse-serratus* (a sunflower), and *Zizia aurea* (an umbel), were studied intensively.

The Robertson collection of notes has been reexamined so that our present-day collection of bees can be compared statistically with that of 70 years ago. Examination of several bee genera shows surprisingly few deletions in the fauna. That is, most species of native bees which Robertson collected 70 years ago were found today on the same flowers. However, some species which Robertson found to be uncommon were not found today, probably due to chance. Also, distinct differences appear in the relative numbers of certain species of bees. For instance, *Colletes aestivalis*, abundant in Robertson's time, is rare today and *Andrena nuda*, uncommon in Robertson's day, is now a common bee.

The field work for this project is being completed this fall. The specimens are being identified and the information collated. We can summarize at this point by stating that although the bee fauna has changed since 70 years ago (probably due to man's activities), no large decrease in the bee fauna has occurred, as has been reported for some insects in certain European areas.

Microspores in Deep-freeze

Since Pasteur found that an infectious agent was responsible for a disease in the silkworm, entomologists have been aware that diseases occur in insects. Many different insect diseases have been described, but in many cases the viable infectious disease agent is no longer available for further research.

An interesting group of organisms which causes insect disease is composed of very tiny, spore-forming, single-celled animals called Microsporidia. Microsporidia are obligate cytoplasmic parasites, most of which infect insects by the ingestion of the resistant spore. Over 150 different species of Microsporidia have been described from insects, but usually only stained slides of dead, fixed Microsporidia are available for study. This is understandable since spores of most species of Microsporidia can live outside the insect host for only a few months to a year. It is unfortunate that viable spores of many of the described species of Microsporidia are not available for study since many of these Microsporidia are important as naturally occurring biological control agents and some have a potential for use in biological control programs.

Survey entomologist J. V. Maddox is interested in the long-term storage of these Microsporidia and has been able to store spores of some Microsporidia, submerged in

Spores of the microsporidian *Nosema necatrix* which infest armyworms (*Pseudaletia unipuncta*). (Microphoto by J. W. Maddox.)

liquid nitrogen (−196°C), for over five years with almost no loss of viability. It now appears that spores of many microsporidian species can be stored in liquid nitrogen for very long periods of time. Maddox now has about 20 species of Microsporidia stored in liquid nitrogen and as susceptible insect hosts are available and as time permits, Maddox and his coworkers are removing these Microsporidia from liquid nitrogen and examining some of the characteristics of these interesting little insect pathogens. Such things as host range, pathogenicity, resistance to environmental conditions, methods of transmission, effect on the infected host, and the life cycle of these Microsporidia are being investigated. We hope to better understand the role of Microsporidia as natural control agents in insect populations and determine if any of these Microsporidia can be used in biological control programs.

Aquatic Plant Control

By midsummer many ponds and lakes in Illinois have become heavily infested with aquatic plant species. Frequently, as these plants mature, the pond or lake also becomes infested with filamentous algae which cling to the submersed aquatic plants. This causes the unsightly appearance of many bodies of water in midsummer reducing fishing, swimming, and boating activities. In order to attempt the control of filamentous algae in Allerton Lake 4-H Camp near Monticello, aquatic biologist Robert C. Hiltibran first tried to control aquatic plants. The sago pondweed plants (*Potamogeton pectinatus*) were eliminated by the application of Aquathol-K (Pennwalt Corporation) at a rate of one part per million. Some filamentous algae developed but without the aquatic plant residue a severe infestation of algae did not develop. Most of the water area normally infested remained free of aquatic plants and algae and, therefore, was usable for boating and fishing.

Development of new aquatic herbicides has been reduced during the last few years. Therefore, an attempt is being made to develop new uses of known herbicides, particularly against aquatic plants which have been difficult to control. Spatterdock (*Nuphar advena*) apparently is not susceptible to many aquatic herbicides, but recently spatterdock has been found to be susceptible to dichlobenil. However, dichlobenil has been approved as a preemergent aquatic herbicide only, and before this chemical can be used a change in the registration will be necessary. Cabomba (*Carboma Caroliniana*) is not susceptible to many aquatic herbicides. Recent results indicate that granular 2,4-D suppresses the growth of cabomba and, if applied early in the growing season, substantially reduces the growth of cabomba.

Herbicide combinations have been found to be more effective than when either is applied alone. A mixture of diquat and copper was found to increase the effectiveness of diquat on aquatic plants susceptible to diquat. However, the diquat-copper complex will have to be checked against other species susceptible to diquat before a general recommendation can be made.

Hydrothol-47 which is effective against algae is very toxic to fish. But newer formulations have suggested new uses and 100 pounds of granular Hydrothol-47 per sur-

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face acre eliminated stands of leafy pondweed (*Potamogeton foliosus*) and small pondweed (*P. pusillus*) with no loss of fish.

These new developments in aquatic plant control were summarized and released in April of this year. The leaflet entitled "The Chemical Control of Some Aquatic Plants" is available from the Survey upon request.

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OCTOBER 1972, NO. [illegible]

Applying the Pressure

Injection of solutions into trees for control of disease or insect pests is an intriguing method of shade tree care. Plant scientists have used this method for years, although results in general have been highly variable and few injection techniques have found practical application. Self-styled "tree doctors" have used injection methods in claims of control or "cure" of tree pests but few of these claims have withstood scientific scrutiny.

Since all fungicides and insecticides are now under intense investigation of their effect on the environment, tree injection, which can reduce the chances of environmental contamination, offers a highly desirable method of applying pesticides for disease and insect control.

Early tree injection methods involved the introduction of limited volumes of solution, using gravity flow to force the liquid into holes bored into the trunk. Recently, researchers have developed equipment to inject liquids under pressure; however, special pressure tanks are usually required. Many compounds may be toxic to the tree if injected in concentrated form, but since a considerable quantity of material is needed to be effective in large trees, a method was needed to inject large volumes of dilute solutions into trees.

For over twelve years, Survey plant pathologist E. B. Himelick has tested methods of injecting solutions into trees. Simple methods using various types of bottles attached by tubes to holes in the trunk have been successful in treating seedlings or trees up to 8 inches in diameter. This method has disadvantages, however, since the containers must be left attached to the trunk for several hours (in some cases days) before all the liquid enters the tree. In addition, some chemicals precipitate out of solution, clogging the vessels at the point

Attachment of injectors to the trunk of an elm for injection of large volumes of liquids under pressure. (Photo by E. B. Himelick.)

of injection and preventing uptake of the liquid.

To overcome the many drawbacks of the older methods, Dr. Himelick has recently developed and successfully tested a technique for injecting large volumes of dilute solutions into trees under pressures ranging from 100 to 400 pounds per square inch. The technique employs easily fabricated injector screws which are screwed into holes in the trunk with a wrench, making a tight, strong seal. The injectors are attached by high-pressure hoses to either a hydraulic sprayer tank or a reservoir tank pressurized with a compressed gas tank. The pressure is slowly raised until the desired amount of liquid is forced into the tree. Using this technique, Dr. Himelick has been able to inject over 20 gallons of solution into elms 30 inches in diameter within twenty to thirty minutes, a much larger volume than achieved with older methods. After injection, the injector screws are removed and the holes plugged to prevent infection and to allow the bark to grow in and seal the holes.

Pressure injection has given good distribution of dyes and soluble chemicals in the trunk and crown of treated trees. In addition, Dr. Himelick has observed that injected chemicals move both upward into the crown and downward into the roots. Therefore this technique has potential use for treatment of various root problems. Although the technique was developed to inject chemicals into trees for control of vascular diseases, it may be used to inject systemic insecticides and plant nutrients. The use of the injector screw, along with a readily available hydraulic sprayer, will enable the professional arborist to treat a tree safely and economically within a few minutes and avoid contamination of the environment with toxic pesticides.

Seed Corn Beetles — Unjustly Accused?

In the past, practically any insect that appeared regularly and in sizable numbers in a damaged crop field was considered to be a pest of the crop, regardless of the nature of the beast. It was easier to apply an insecticide to prevent potential insect damage than to determine whether sprays were really needed.

Now that pesticides are under close scrutiny as environmental pollutants, scientists are taking a closer look at some of the lesser known insects that occur on crops to see if these are really harmful insects or potentially useful species. A case in point involves the seed corn beetles. Aside from the fact that adult beetles have been associated with damage to germinating corn, very little is known about them.

In Illinois, a complex of five species of two genera of the beetles are present. One genus is known as the striped seed corn beetle, the other as the slender seed corn beetle. Since pesticide recommendations are made annually in Illinois for control of these insects, Survey entomologist R. D. Puasch in 1972 initiated a study of the life histories of the seed corn beetles. He hopes to learn as much as possible about the insects and to see whether they are truly economic pests that require control measures.

The striped and slender seed corn beetles belong to a family of insects in which both the larvae and adults are usually carnivorous and only a few feed on other foods such as seeds. The mouth-parts of larvae and adults of the seed corn beetles are of the carnivorous type. This indicates that the beetles probably prey on other insects and the use of insecticides for their control may actually be detrimental to the corn crop.

One of the goals of this new study is the development of techniques for rearing seed corn beetles in the laboratory. If the beetles can be reared, immature stages found in the field could be identified based on larval keys developed by Survey insect taxonomists, something that is not possible with our present knowledge. In addition, laboratory rearing would enable a much more detailed study than is possible under field conditions.

Since the seed corn beetle adults are attracted to light, especially black light, they are fairly easy to trap in the field. Large numbers have been obtained in traps locally during the beetles' active season, April to October. Some of these beetles are retained

for laboratory rearing studies, others are placed in cold storage for studies during the winter months. The remainder are released in cages in the field so that studies on overwintering can be made on an infested area under natural conditions.

During the season, Dr. Pausch dissects beetles from each night's trapping to study egg development and sex ratios and determine when egg laying occurs. Climatic factors such as night temperature of soil and air, cloud cover, and nocturnal rainfall are also being studied since they may effect the movement and population buildup of these insects. The food habits, local distribution, and physical development of the larval stages compose another phase of the project. By studying both the larvae and adults in as many ways as possible, it is hoped that a fuller understanding of these beetles will be achieved.

Thrush Foolers Foiled

Although it is obvious that migrating birds are able to orient their direction of flight during spring and fall migration, how they do this is an intriguing question. Do they orient by the sun, moon, stars, wind direction, or a combination of these factors? Do they use different orientation mechanisms during the daylight hours than they do at night? Many of these questions have not been satisfactorily answered.

To study animal movements, Survey wildlife specialist W. W. Cochran developed a minute radio transmitter, which can be attached to even a small animal. In this way the animal's movements can be followed electronically without its knowledge and without disturbing its natural environment. This has proven to be a very handy tool in migrational studies.

From 1965 to 1971, data were collected on the nocturnal flight directions of three species of thrushes during their spring migration through Illinois and beyond. These data show that thrushes have what amounts to an internal compass and seem to 'know' one direction. All birds had been radio-tagged and released as soon as possible at the point of capture. Thus the data represent the natural behavior of thrushes as near as possible.

To see if the thrush's orientation mechanisms could be disrupted, in 1972 Mr. Cochran transported radio-tagged birds about twenty miles and held them so that they could not see their surroundings. They were then placed into a clear plastic dome and released either after the sun's direction was reversed with a large mirror or after all traces of daylight were gone. When it was completely dark, the dome was raised and the birds' movements were radio-tracked.

When the sun direction was reversed, the birds initially headed in a down-wind direction but soon reoriented to the normal up-wind direction for migratory flight. In the cases where the sky was overcast, giving an indistinct sunset direction, initial flights were down-wind but gradually shifted to the normal direction.

These results suggest that thrushes can orient without visual clues before or during a flight, but when released with an improper or indistinct sun direction, they go through a period of disorganization followed by properly oriented flight.

Since experiments of this type must be done with whatever weather conditions prevail, and then for only a few weeks in May, it may require several years to test all combinations of wind and sky to gain a better understanding of flight orientation in thrushes. Especially interesting will be conditions when the wind is blowing a direction markedly different from the bird's normal flight direction and when a distinct sunset is followed by overcast before the stars are visible.

Municipal Control of Dutch Elm Disease

Dutch elm disease was first found in the greater Chicago area in 1954. Within three years, fifty-five municipalities in this area organized disease control programs, but many others did not attempt to combat the disease. Control programs were based on recommendations from the Illinois Natural History Survey and included (1) prompt removal of all dead and dying elm material to prevent buildup of populations of the bark beetles that carry the disease fungus, (2) spraying of healthy elms with insecti-

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cide, and (3) where required, application of soil barriers to prevent spread of the disease fungus from tree to tree through root grafts.

To determine the effectiveness of municipal control programs, Survey plant pathologist Dan Neely has submitted a questionnaire annually since 1957 to a responsible official of each community. A recent summary of this information has revealed some rather interesting and significant trends.

In cities with control programs, sanitation (the removal of dead and dying elm wood) has been the foundation of success. Without prompt removal, elm losses have steadily increased regardless of other practices employed.

The number of cities applying insecticides to healthy elms is decreasing. In 1957, over fifty-five cities in northeastern Illinois used insecticides, mostly DDT, on parkway elms and private property elms bordering streets. In 1966, thirty-four cities sprayed elms, twenty-three with DDT and eleven with methoxychlor. In 1971, only eighteen cities sprayed elms and all used methoxychlor.

A summary of twenty-six Illinois cities that used sanitation and spraying control procedures from 1957 through 1966 revealed that in sixteen of the cities annual losses during the ten-year period averaged less than 1 percent of the original elm population. Eleven of the twenty-six cities discontinued spraying between 1967 and 1971 but all twenty-six retained strict sanitation procedures. Losses in these eleven cities have not risen appreciably compared to those with spray programs, indicating that sanitation may still be the most effective procedure for controlling Dutch elm disease. The long-range effects of discontinuing spray operations, however, may not become clear for several more years.

Losses due to Dutch elm disease increased in most of the twenty-six cities (all of which were near Chicago) during 1969 and 1970, when the city of Chicago failed to remove diseased trees promptly. Sanitation was again enforced in Chicago in 1971.

The practices employed by Illinois cities to control Dutch elm disease are indirect, demanding, and expensive, but if stringently followed, they result in acceptable disease losses. Many of the cities with continuous control programs have elm losses of only 10 to 25 percent of the original elm population for the fifteen years for which data are available. This is much lower than in cities without control programs. According to Dr. Neely, a mature tree population can be retained by municipalities if control practices are followed and if elms lost to Dutch elm disease are replaced with other desirable tree species.

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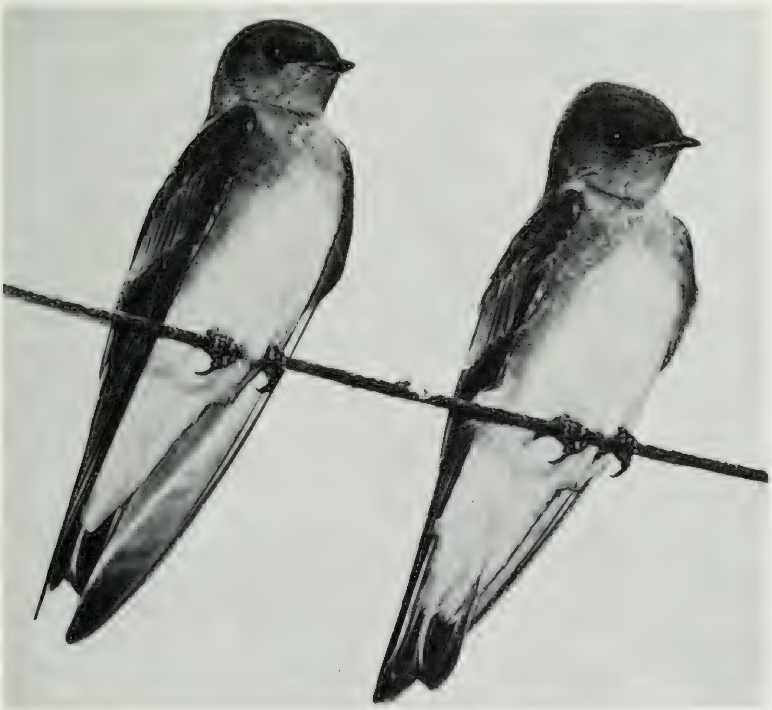
Illinois Swallows

Most Illinois citizens are familiar with the aerial acrobatics of birds of the swallow family. Even in cities the purple martins can be seen swooping and diving over lawns and buildings. In rural areas the common barn swallow has been a delight to many a child while lying on his back watching this small bird seemingly play tag with clouds. In some parts of the state large aggregations of barn or cliff swallows or some other species can be observed in spring and fall roosting by the hundreds on telephone lines.

A recent Survey publication by ornithologists Richard and Jean Graber and Ethelyn L. Kirk, "Illinois Birds: Hirundinidae" (*Biological Notes* No. 80), summarizes the status and population information for each of the seven species of swallows known to occur in Illinois and emphasizes the deficiencies in the available knowledge concerning each species.

Of all the species of Illinois songbirds, those which perhaps best lend themselves to accurate population studies are the colonial species of the swallow family. With enough people contributing data, it should be possible to follow the ups and downs of the state-wide nesting populations of at



Rough-winged swallows in fresh plumage of early August. (Photograph by Richard R. Graber.)

least the cliff swallow, the bank swallow, and the purple martin, and perhaps also the rough-wing and tree swallows, and to do so with an accuracy ordinarily achieved only in relatively small census areas. The authors of this paper on swallows hope that all students of Illinois birds will take heed and help to improve the knowledge concerning Illinois populations and thus provide a better basis for conservation decisions.

Historical evidence is presented that at least cliff and tree swallow populations have waned, particularly in southern Illinois. Among other interesting points made in the paper is the very marked difference between eastern and western Illinois in the swallow migration, with the western section having many times the number found in the east.

For those interested, copies of the swallow publication are available upon request from the Illinois Natural History Survey.

Sangamon Studies

Illinois is a state of rivers. It is not unusual, therefore, that the Survey's Aquatic Biology Section has directed a substantial portion of its research toward flowing water systems. Because of research of the Natural History Survey, the Illinois River is often considered to be one of the most thoroughly studied rivers in the world. Current research on the Kaskaskia River and the Salt Fork of the Vermilion River have placed these streams high on the "most thoroughly studied" list. Work on a new program under the direction of Survey aquatic biologist Warren U. Brigham promises to add the Sangamon River to this list.

A multidisciplinary ecological research program has been established in light of the proposed development of the controversial Oakley Dam and Reservoir, the Friends Creek subimpoundment, and the Sangamon River Valley green belt. This program seeks to measure ecological conditions and processes before, during, and after construction of the Oakley Project. Within the framework of the overall program, the research being conducted by Warren Brigham and his associates concerns those factors which specifically relate to the aquatic fauna and flora and the physicochemical environment of the Sangamon River.

Presently, 15 sampling stations have been selected and weekly collections of water samples are being analyzed for 27 different parameters. In the near future, 14 additional parameters, as well as fish, benthos, plankton, and periphyton studies, will be added to the program. By summer 1973 a monitoring station will be in operation in Allerton Park near Monticello. This station will have provisions for continuous monitoring of up to 24 physical and chemical parameters. Further, water samples will be withdrawn automatically from the stream at hourly intervals in order that additional analyses may be performed in the laboratory.

The large volume of information gathered in the Sangamon River study will necessitate use of a computer for the annual analysis of data. To date, preliminary findings confirm the suspicion of high nutrient concentrations (nitrates and phosphates) in the Sangamon, especially below Decatur. Further, dissolved oxygen concentration is generally lowest below Decatur. Turbidity is quite high throughout the Sangamon Basin.

Upon completion of the Oakley Project, several limnological changes in Lake Decatur are anticipated. Oakley Reservoir should act as a turbidity trap resulting in a clarification of the water of Lake Decatur. This, in turn, could result in an increase in the productivity of Lake Decatur. Detection of changes such as this are among the long-term goals of Brigham's Sangamon River study.

Mighty Mites May Help

When persistent organophosphate insecticides which control a wide range of insects were introduced into fruit pest control, a new possibility of pest management came into being. The naturally occurring predatory mite called *Typhlodromus fallacis* (Garman) became resistant to the widely used Guthion insecticide in about four years. This same mite is also resistant to certain similar organophosphates as well as many of the fungicides used in orchards.

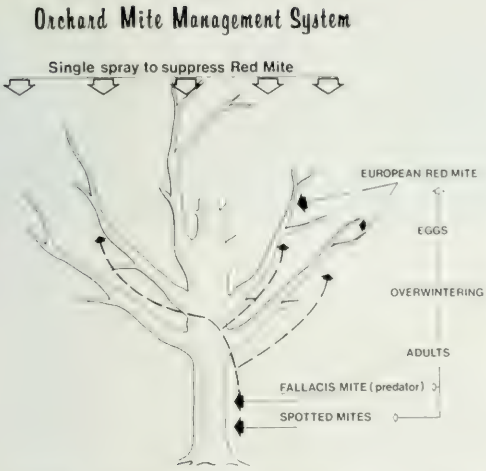


Diagram showing salient ecological facts concerning life histories of mites on orchard tree.

It is not resistant to certain chlorinated hydrocarbon and carbamate insecticides and a few miticides.

The diagram gives basic details of the ecological situation. The predatory mite along with one kind of plant-feeding mite, the spotted mites, overwinter as adult females under protective bark or in the ground litter and so the predator is with one source of food immediately in the spring. Spotted mites are not always present in discernible numbers in orchards. The main pest mite, European red mite, *Panonychus ulmi* Koch, overwinters in the egg stage on roughened areas of bark near leaf buds on all parts of the tree. Red mite females lay eggs until frost which may be much later than the time that spotted mites and *fallacis* mites go into hibernation. This, plus higher percentage of winter mortality among *fallacis* mites, often gives the red mites great numerical advantage.

According to Survey entomologist R. H. Meyer, a very safe natural control agent should be applied early in the spring as the buds are starting to grow. This is an application of a highly refined paraffin oil which evaporates in a very few days. It suffocates red mite eggs and certain other pest insects such as scales. The oil does not harm the predatory mite or spotted mites when applied early, as they are still in protected hibernation sites. The population increase of red mites as it approaches sufficient numbers to damage the leaves must be carefully watched. The most critical time is three to five weeks after bloom but may occur later. The main variables operating when this threshold occurs are the relative number of predator and prey populations that go into and come through the winter, the thoroughness of the oil application, and the nature of the weather situation which influences all other factors. Predictive methods to take in these variables have not been attempted because they would have to be worked out in each situation. It is more practical to watch for the increase of mite populations. When red mite populations reach threatening levels, a miticide that is safe to the predator mites but will suppress the red mite population should be applied. In about a fourth of the time, no suppression is needed. If the suppression spray is applied at the right time and in the right amount, one application is usually sufficient. Once predators reach high enough ratios to control red mites, they maintain control for the remainder of the season.

This management technique has been in operation very successfully for five years. When it fails one or both of two mistakes are usually made. A chemical pesticide harmful to the predators has been used or the early suppression application was not used or was delayed too long.

Prairie Fire and Insects

Mankind, from the Stone Age to the present, has purposefully or accidentally set fire to large acreages in all parts of the world. In the dry season, fires are regularly set in Africa, South America, Australia, New Guinea, the Philippines, and elsewhere, and until recently, in many parts of the United States. In most cases these fires have reduced the forests and allowed certain resistant grasses to become the dominant vegetation. It is generally agreed that savannah-dwelling game birds and mammals profit from such burning. A successional habitat, well suited to them, is maintained by these fires. But how do fires affect the lesser animals, especially the duff insects, the insects of prairie forbes, and insect parasites? Were fires natural in the

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prairies, perhaps set by lightning, before the coming of man? Can fire be a proper technique or tool to preserve those few remnants of our native grasslands that have been dedicated as nature areas or living museums?

To answer some of these questions, Survey entomologist Lewis J. Stannard has been collecting indicator insects, species belonging to the order Thysanoptera or thrips, from burnt and unburnt areas to determine their survival rate and rate of redispersal into altered habitats. All of them are integral components of the environment. Samples have been taken from various prairies: the sand prairies along Lake Michigan, the Central Illinois tall grass prairies, and prairie openings as far south as Pope County along the Ohio River. Recently Goose Lake Prairie has been added to the areas being monitored.

From studies made to date it can be concluded that fire destroys most of the populations of duff-inhabiting thrips. Their rate of return after the fire is as yet unknown and may take years, as the species involved are usually wingless and cannot return readily. If the fire is not too hot and takes place early in spring when the ground is wet, some islands of unburnt patches occur with their insect populations more or less intact. Even parasites in singed mice nests may survive the initial burn but later disappear when the mice fail to return to the exposed nests. It is almost certain that closely spaced, repeated fires could exterminate prairie insects in a nature preserve and, if there were no unburnt prairie nearby, reinvasion after burning might never be possible.

In Goose Lake Prairie (under experimental burning management) and in certain accidentally burned areas in state parks and nature preserves the thrips populations will be kept under surveillance for the next few years. The recovery of these populations can be studied and, perhaps, provide us with information about fire as an ecological force largely under control of man in Illinois.

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Climate Affects Gladiolus Corm Rot

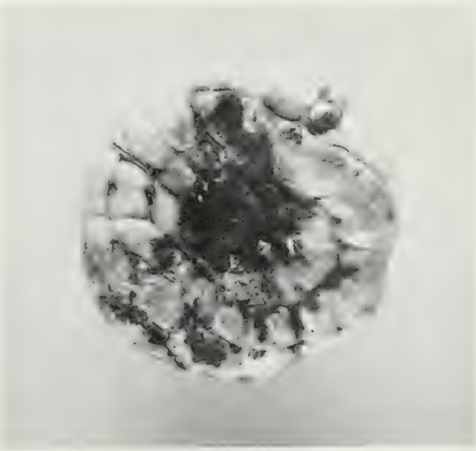
Although many crops are grown in Illinois besides corn and soybeans, few people realize that there is a gladiolus industry in the state. Over 1,000 acres of gladiolus are produced annually in Illinois, mostly by a group of growers in Kankakee County near Momence. Both cut flowers and corms (commonly called bulbs) are harvested and shipped throughout the country.

Gladioli are propagated vegetatively by planting corms so that varieties will reproduce true to type. Since corms are attacked by several disease organisms, particularly corm rot fungi, disease control is essential for survival of the gladiolus industry. For the past thirty-three years, Survey plant pathologists have conducted annual corm treatment tests with fungicides to provide the most effective disease control recommendations possible. One facet of this research is the identification of corm rot disease organisms. Due to this constant surveillance, one of the major gladiolus diseases known as Curvularia disease was found in Illinois fields in 1954.

Since the fungus that causes Curvularia disease is a potentially destructive pest, considerable research has been conducted in Illinois since 1954 to find out what factors influence disease development. Records of the incidence of Curvularia lesions on corms harvested from test plots from 1954 through 1971 show that prevalence of the disease is associated with certain weather conditions. Survey plant pathologists R. S. Perry and J. L. Forsberg recently correlated records of disease incidence with weather data for the 18-year period and came up with some interesting conclusions.

Temperature appears to be the primary factor influencing disease incidence. When the average temperature during the growing season was above 69.4° F, disease incidence was high, whereas it was moderate or low when average temperatures were less than this figure. Rainfall did not seem to be a factor except in years when temperatures averaged higher than 69.4° F, in which case heavy rainfall appeared to lower disease incidence. It was concluded that high soil moisture serves to reduce soil temperatures. In Illinois, where symptoms of the Curvularia disease occur primarily on the underground parts of the gladiolus, factors that influence soil temperatures are of major importance in the development of the disease.

Such information is useful since knowing how much disease damage can be expected



Curvularia rot lesions on a gladiolus corm. (Photo by former Survey photographer William Clark.)

in a given year aids in evaluation of control measures.

Parasites on Parasites on . . .

Most people are familiar with the use of insecticides to control insect pests of crop plants. A lesser known method of insect control is the introduction or encouragement of predators and parasites that act as control agents by keeping populations of economic insects at low levels. Many predators and parasites have been collected abroad and introduced under controlled conditions on crop plants in this country to see if they might be of value as biological control agents for insect pests.

About two years ago, Survey entomologist C. E. White received from the USDA one hundred aphid mummies containing a tiny wasp that had been imported from France. The plan was to rear this wasp in the laboratory for release and possible establishment as a biological control agent for the corn leaf aphid that has been so abundant in Illinois corn fields in recent years. This naturally led to a study of the parasites already at work in these corn fields. The newly introduced wasp would either have to find a new niche and live in harmony with the parasites already present, or it would have to replace those present.

By collecting approximately 19,000 living aphids and 700 mummified aphids from Illinois corn fields in the summer of 1971, Mr. White and his associates were able to rear out five different species of parasitic wasps. These little wasps, about ⅛ inch long, are all known only by their scientific names and have never been given common names. Although many wasps were reared from the aphids collected alive from the corn fields, the aphid always died and became a mummy before the adult wasp parasite emerged. With one wasp species, 71.6 percent of the adults emerged from aphids collected alive and the rest from aphids collected as mummies. A second species had 62.5 percent emerge from aphids collected alive and the rest from those collected as mummies. A third species had 2 percent emerge from aphids collected alive and the fourth and fifth species had no adults emerge from aphids collected alive and all adults emerged from aphids collected as mummies.

These figures indicate that the first two species are probably primary parasites or parasites which attack and kill the corn leaf aphid, whereas the other three species are predominantly secondary parasites or those that attack and kill the primary parasites within the mummified aphids. The first species mentioned is definitely known to be a primary parasite of the corn leaf aphid. Although there is some controversy about the other four species, they have been reported as both primary and secondary parasites. Results of laboratory experiments conducted in 1971 indicate that only the first species is a primary parasite of the corn leaf aphid and the other four may be secondary parasites of the primary parasite. If this is true, then more than half of the beneficial parasites of the corn leaf aphid were being killed by secondary parasites in Illinois corn fields in 1971. Data for 1972 indicate that the percent being killed by secondary parasites may be even higher.

It is therefore evident that all biological control is not beneficial. Will it be necessary to release parasites of parasites of parasites to achieve good biological control of corn leaf aphids? If so, will the parasites of the parasites of the parasites also have parasites? Good grief! Biological control is a very complex undertaking and much study and research are still needed before such measures are considered practical.

Managing Roadsides for Pheasants

One of the most popular upland game birds in many areas of the Midwest is the ring-necked pheasant. High density populations of this colorful bird in the intensively farmed cash-grain region of east central Illinois has made this area a Mecca for pheasant hunters for many years. Now, however, intensive farming practices and changes in crop acreages are putting pressure on the survival and reproduction of pheasants.

In central Illinois, the ring-necked pheasant has adapted well to intensive farming and has utilized hayfields as nesting cover. Unfortunately for the pheasants, farmers are planting more and more acreage in

Roadside seeded and managed for pheasant nesting cover near Sibley, Illinois. (Photo by Survey photographer Wilmer Zehr.)

corn and soybeans while hayfield acreage is steadily decreasing. This pressure is forcing pheasants to make increasing use of roadsides as nesting cover. Since it is highly unlikely that farmers can be motivated to plant more acres to hay crops to increase pheasant production, wildlife specialists are searching for practical methods of managing roadsides to provide nesting cover.

Several problems have been encountered in managing roadside cover in Illinois. First, the weeds and old bluegrass growing along roadsides are not often ideal for pheasant nesting. Second, it is common practice for farm operators to mow roadsides in spring and early summer. Since successful nesting of pheasants requires that cover be available through mid to late July in central Illinois, early mowing of roadsides is highly detrimental to pheasant reproduction.

To determine the feasibility of managing roadsides as a practical means for establishing nesting cover, a long range study was initiated in 1968 under the cooperative direction of Survey wildlife specialist G. B. Joselyn and G. I. Tate of the Illinois Department of Conservation. A twenty-square-mile area with eighty-one miles of roadside near Sibley, Illinois, was selected for the study. Cooperation from farm operators, county and township officials concerned with road management, and other interested state and local personnel was enlisted with excellent results. In 1968, roadsides in the study area were seeded with bromegrass and alfalfa and rolled where necessary. Lime, fertilizer, and weed killer were applied after seeding to establish high quality hay cover. Farm operators in the test area were asked to delay annual mowing of roadsides until after the nesting season.

Data collected since this study began show that the number of pheasants hatched on the managed roadsides was substantially increased over prior years. A cost analysis run on the entire management operation indicated a cost of $139 per mile of roadside. Since the life expectancy of the seeding is estimated at ten years, the annual cost amounts to about $7 per acre per year. The researchers feel that this cost could be reduced by as much as 50 percent, however, by modifying the seeding and management operations.

Whether this type of program of roadside management to provide nesting cover for pheasants will be accepted in the future remains to be seen. Thus far results appear very promising when compared to those reported from methods tried in other states. If the proportion of total land acreage in hay continues to decline, pheasants will be forced to rely increasingly on roadsides as nesting cover. Thus, seeding and management of roadsides may become a valuable and accepted method of wildlife management.

Stored Grain Pest Problem

The larval or worm stage of the Indian meal moth is very destructive to stored grains, cereal products, dried fruits, and shelled nuts in many parts of the world. The larvae spin silken threads which cause infested foods to be matted together, thus rendering them unfit for human consumption. In stored grains, the larvae usually begin feeding on the seed germ, destroying the ability of the grain to germinate and making it useless for seed. Corn, wheat,

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oats, and barley are among the grains damaged. It is estimated that each year Illinois farmers lose about 10 percent of their farm-stored grains to insects. Of these insects, the Indian meal moth must be considered among the most important.

For over ten years, malathion has been widely used in Illinois as a grain protectant on stored wheat. However, in the last three years there has been mounting evidence that in some parts of Illinois the Indian meal moth is no longer controlled by this insecticide.

Since several microorganisms that cause diseases of the Indian meal moth have been reported from other parts of the world, Survey entomologist R. K. Sprenkel began a study in 1970 to determine what diseases of this pest are present in Illinois and what effect they have on their host.

Two disease organisms have been found in the Indian meal moth in Illinois and both are spore-forming protozoa that infect the larval or worm stage. One of these is very widespread and all of the fourteen grain bins sampled over an eight-county area contained infected meal moth larvae. Usually 10 to 15 percent of the larvae were infected, but in some bins as high as 88 percent were infected. In the laboratory, the larvae were easily infected with the organism but few larvae died. Most of the infected larvae developed into infected adults, the females of which laid fewer eggs than healthy ones.

The second protozoan is much less common in Illinois but laboratory studies show that it causes high mortality in the Indian meal moth. As few as ten spores are able to kill half-grown larvae and infected larvae usually die within ten days.

Why the more lethal organism is not more widespread in the state is not known but one explanation now under investigation involves the ability of the organism to withstand the temperature extremes encountered in Illinois grain bins. A second explanation being studied is that the organism may be so highly lethal to larvae that infected adults are rarely produced. Since it is the adult stage of the meal moth that travels from bin to bin, the disease organism would have no way of being transferred to a new grain bin.

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